

**Environmental Effects of the Coffee Crisis:
A Case Study of Land Use and Avian
Communities in Agua Buena, Costa Rica**

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A Thesis

Submitted in Partial Fulfillment of the Requirements for the
Masters of Environmental Studies Program
The Evergreen State College

December 2005

This Thesis for the Master of Environmental Studies Degree

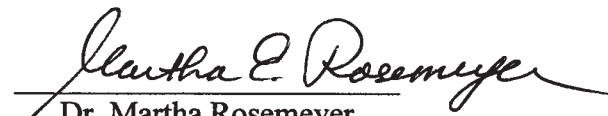
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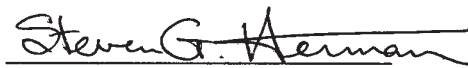
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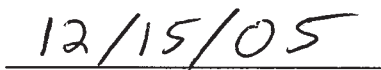
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Abstract

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The last 15 years have seen the most dramatic and prolonged collapse in coffee prices in the history of the global coffee trade. In response to this “coffee crisis,” many coffee farmers have been forced to abandon their land or change to other crops, including cattle pasture. This study looks at the environmental effects of these decisions at a local scale, focusing on the district of Agua Buena in southern Costa Rica. Interviews with 59 farmers were used to assess the nature and extent of land-use change on coffee farms, and 96 timed area-search bird surveys were used to assess the effects on avian communities of conversion of coffee to pasture. The interviews revealed that, in the study area, farmers were changing from coffee to other crops, with 93.3% of respondents listing coffee prices as a motivating factor in their decision. Pasture represented, by area, 64.3% of the land area converted, with other crops and land abandonment representing 15.3% and 14.0%, respectively. The bird surveys showed a reduced diversity at the species level, and reduced richness and diversity at the family level. The bird surveys also revealed changes in community composition with conversion to pasture – most notably the disappearance of four of five detected species of understory insectivores, a nine-fold increase in the relative number of detections of sparrows and finches (family Emberizidae), and a four-fold increase in the relative number of detections of granivores. The study concludes that, due to the scale of conversion of coffee to pasture revealed by the interviews, and the diminished habitat quality in pasture as indicated by the bird surveys, the coffee crisis has had negative effects on biodiversity at a local scale. The conclusions suggest that new price and supply controls are desirable to mitigate both the environmental and social effects of the coffee crisis.

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Acknowledgements

This work would not have been possible without the assistance of a great many individuals, only a few of whom I will be able to name here. My primary reader, Dr. Martha Rosemeyer at Evergreen, has provided constant support and assistance at a level that defies any superlatives that could be selected to describe it. I could not have hoped for a better advisor, and I feel unbelievably fortunate to have benefited for the past three years from her knowledge, wisdom, and compassion.

My two other readers, Dr. Steve Herman at Evergreen and Dr. Catherine Lindell at Michigan State University, made valuable comments and suggestions during the project and provided feedback on the draft manuscript. Dr. Ted Whitesell at Evergreen, and Jai Ranganathan at Stanford University, also provided input and comments on portions of the manuscript. Dr. Gretchen Daily at Stanford University, and John Alexander at the Klamath Bird Observatory, assisted with suggestions during the project planning. Rip Heminway at Evergreen provided hours of valuable assistance with GIS.

Dr. Çağan H. Şekercioğlu at Stanford University graciously allowed me to accompany him on two mist-netting trips to help learn the birds of the study area, reviewed two early drafts of my prospectus, and provided suggestions and feedback throughout the project. Dr. Karen Holl at the University of California, Santa Cruz, reviewed two early prospectuses, provided aerial photos of the region, and made suggestions during the research. Both Jim R. Zook and Dionisio Castro took me birding in the study area on several occasions. Dr. Bruce Haines at the University of Georgia, Dr. Fred Werner at Cornell University, and Dr. Ken Orvis at the University of Tennessee all provided valuable comments and suggestions on various aspects of the project. The early guidance of Dr. Thomas W. Sherry at Tulane University helped me to begin to formulate a research question, and allowed me to acquire the background necessary to pursue this work.

Darryl Cole-Christiansen at Finca Loma Linda provided invaluable logistical support by making the arrangements for a homestay, assisting in transportation, and allowing the use of his grounds for birding practice and his library for research. Rodolfo

Quirós at the Wilson Botanical Garden generously allowed me to use the Garden's library and provided feedback, contacts and suggestions. The Mendez-Gutierrez family allowed me to stay in their home, assisted with the development of interview questions, and helped me to locate research sites. Javier Cedeño and Coopabuena allowed me to use their computer and telephone, and provided logistical support, suggestions and information throughout the project. The Cordero Campos family also allowed me to use their telephone frequently. Xinia Mesa and Luis Campbell provided a much-needed home base in San José.

I am grateful to Omar Morera Barrantes, Carlos Jiménez Alvarado, Marco Salazar, Eladio Mendez, Henry Prendas Fernández, Roberto Jiménez, the Corporación Cafetalera La Meseta, and two additional landowners for allowing me to use their farms for my bird surveys. I am also thankful to everyone who responded to questionnaires or allowed themselves to be interviewed during the course of the project. The managers of Finca Rio Negro and the Hartmann family allowed me to investigate their properties as potential research sites during project planning, and provided logistical support while I was doing so. This thesis received financial support from the Studebaker Foundation and the Evergreen State College Endowment.

By far the biggest debt of gratitude I owe is to my husband, Luca Pellanda, who has allowed both our lives to be turned upside down in the pursuit of the completion of this thesis. Words fail in attempting to describe the value of his contributions to this work. For the unending and unconditional emotional and financial support, for believing in me when I myself couldn't do so, for being Helium to my Strindberg, and for the hundreds of small things that have kept me going for the past three years, this thesis is as much the fruit of his labor as it is mine. I am also thankful to the rest of my family for their emotional and financial support: my mother, Marilou Rickert, who also proofread the manuscript and helped "hold down the fort" during my time in Costa Rica, and my mother- and father-in-law, Bruna and Renato Pellanda.

All of these individuals, and many others, have contributed to and improved this work, but the full responsibility for any errors it contains is, of course, my own. I have almost certainly unwittingly omitted a number of people to whom I owe thanks, and to these I offer my apologies.

I. Introduction and Background

1. Introduction and summary

If you visited a coffee-growing region anywhere in Costa Rica in 2003, you would hear and see references to “the crisis.” No one there needs it explained to them: in this small Central American nation, rapidly diversifying its economy but still heavily dependent on agricultural exports such as coffee and bananas, “the crisis” is in the newspapers, on the TV, on billboards, and the subject of books, but most importantly, an everyday reality for tens of thousands of people. The term “crisis” has been used throughout the history of coffee production whenever export prices take an inevitable nosedive. In this case, the term refers to the longest and deepest slump in coffee prices in the history of Latin American production of this commodity.

Many of the brutal economic effects of the crisis on Costa Rica’s 70,000 coffee farmers, who watched the price of their product collapse by 60% or more in just three years, are easy to anticipate. On the surface, the story of Costa Rican coffee farmers is another iteration of the same narrative, repeated throughout modern history, of all small-scale producers of raw materials struggling to survive a volatile world market. The peculiar dynamics of coffee production, described in Chapter 1.3, make the current crisis more complex and intractable than a typical downturn in the price of other types of commodities.

Also not clear are the effects of the crisis on the Costa Rican environment, as farmers are forced to change to different products, or to leave the land entirely. It is these environmental questions, placed in the context of the economic reality of rural Costa Rica, which this study attempts to answer. In search of those answers, it will examine the effects of the coffee crisis, and responses to those effects, across scales: from individual households and small communities, to the national and international levels.

This thesis first provides an overview of the world coffee market and the sequence of events leading up to and following the collapse of the International Coffee Agreement. Next, it looks at the effects of the price crisis, discussing social and economic effects where they interface with environmental issues, in order to understand

the environmental effects of the crisis and their context. After a brief glimpse of these issues at an international scale, the study focuses in on the Central American country of Costa Rica, then on the canton of Coto Brus, a remote coffee-growing region of that country.

This thesis examines in detail the effects of the crisis in the district of Agua Buena, a region of Coto Brus disproportionately affected by the crisis. At this “micro-“ level, we are able to see a detailed picture of individual responses to the crisis, which then shed light on its large-scale effects. Two specific hypotheses are tested. The first hypothesis predicts that coffee farmers in Agua Buena are responding to the crisis by removing their coffee in favor of cattle pasture. The second predicts that the conversion from coffee to pasture will have a negative effect on bird communities that use the agricultural matrix in the region. The study concludes with a discussion of possible solutions to the crisis.

2. Coffee and the Environment

Agricultural areas take up a significant portion of the earth’s surface, and that proportion is going to continue to increase as we address the need to provide food and goods to a world population that is growing in both size and consumptive ability. It is widely recognized that pristine areas, including protected areas such as reserves and national parks, will not be sufficient to preserve biodiversity in the future (Pimentel & Stachow 1992; Vandermeer & Perfecto 1997; Hughes et al. 2002). In order to ensure the greatest possible protection for wild species, attention needs to be given to the potential benefits and limitations of agroecosystems as wildlife habitat (Vandermeer & Perfecto 1997; Hughes et al. 2002; Jules & Shahani 2003). In many tropical areas, permanent agroforestry systems such as coffee offer a more stable, and environmentally preferable, alternative to such common practices as slash-and-burn farming (Griffith 2000), and environmentalists have recently given a great deal of attention to coffee as an environmentally sustainable crop that, under the right circumstances, can provide important habitat for wildlife. This chapter will review the literature regarding the effects of coffee production on deforestation, biodiversity, and habitat connectivity.

In the case of coffee, a great deal of biodiversity research has compared “shaded” Arabica farms in the Neotropics to primary forest and unshaded coffee monocultures (Greenberg et al. 1996; Perfecto et al. 1996; Greenberg et al. 1997; Johnson 2000; Sherry 2000). Coffee evolved as an understory plant, and shade trees have been used for centuries in coffee production to control yields, coffee quality, the productive lifetime of individual coffee trees, protection from climatic extremes, and pest outbreaks (Beer 1987; Caramori et al. 1996; Beer et al. 1998; Muschler 1998; Soto-Pinto et al. 2000; Muschler 2001).

Unfortunately, while there is a niche market for “certified” shade-grown coffee, the certification process is expensive (Gobbi 2000) and the market for these products is small (Puelschen & Lutzner 1994; Messer et al. 2000). Further, farmers may not actually receive a premium for their certified coffee if there is not also a certified processing plant available to take their product. Those plants that are certified can control the prices paid to farmers, and use regional monopolies to hold prices down (Lyngbaek et al. 1999). Additionally, in optimal growing zones, any shade at all may compromise yields, complicating the economic equation for farmers considering shade-grown coffee (Beer et al. 1998).

Because of these factors, and of powerful pressures from government policies and funding agencies, much of the world’s coffee is now produced on “technified” farms involving few shade trees and heavy agrochemical inputs (Rice 1999; Perfecto et al. 1996; Borrero & Ignacio 1986). In Latin America, sun coffee farms make up about 40% of coffee area (Rice & Ward 1997; cited in Rappole et al. 2003a). Furthermore, only Arabica coffee is grown in shaded systems. Shade is completely inappropriate for Robusta (O'Brien & Kinnaird 2004), the coffee variety grown in lowland regions, including most coffee-growing areas of Asia and Africa. Much of the concern over deforestation arising from coffee production is due to the expansion of Robusta production.

While the information on biodiversity in shade coffee is valuable, therefore, there is little information on other widespread methods of coffee cultivation in Latin American countries. The lack of information on non-shaded systems makes comparison of coffee

farming in general (as opposed to shade coffee farming) with other types of agricultural land use, such as pasture or vegetable crops, difficult. Because, however, of the large number of coffee farms in Latin America that are still planted with some level of shade, and because the research on shaded coffee makes up such a large portion of the ecological literature on coffee, this chapter will review what is known about the environmental costs and benefits of shaded coffee farms in comparison to other forms of coffee production.

Because the purpose of this thesis, however, is to address the environmental consequences of the coffee crisis at multiple scales, and because the local area that serves as a case study for this thesis is dominated by coffee farms with sparse, low-diversity shade trees, this chapter also reviews the somewhat less abundant literature dealing with the impacts of typical coffee production and, where possible, makes comparisons between coffee and other agroecosystems suitable to the same conditions as coffee. While there are many areas of coffee's environmental impact that deserve discussion, such as agrochemical use, water and air pollution from coffee processing, and carbon storage, the focus of this work is biodiversity and associated variables, such as deforestation and habitat connectivity.

Moguel and Toledo (1999) describe five categories of coffee production systems which, although broad, are useful as an aid in discussion of the ecological characteristics of different forms of coffee farming (Figure 1.2.1). "Rustic" plantations are primary forest where the understory has been removed and replaced with coffee plants. In a "traditional polyculture," some of the forest tree species have been replaced by other species, either of commercial value or of use to the farmer. A "commercial polyculture" has had the overstory removed, as well, and replaced it with a mixture of commercially useful trees – typically *Musa* spp., *Citrus* spp., and nitrogen fixing trees such as *Erythrina* spp. and *Inga* spp., and less often trees used for lumber. A "shaded monoculture" is a farm where the shade consists only of a single species, usually *Erythrina* spp. or *Inga* spp. Finally, "unshaded monoculture" is coffee grown in full sun, with no interplanted trees or crops.

Where appropriate, this terminology will be used in discussions of different coffee production systems. The term “sun coffee” will be used interchangeably with “unshaded monoculture.” Where the phrase “shade coffee” is used alone, it will generally mean either that additional information was not available about the level or type of shade, or that the system did not fit into one of Moguel and Toledo’s four categories of shade coffee.

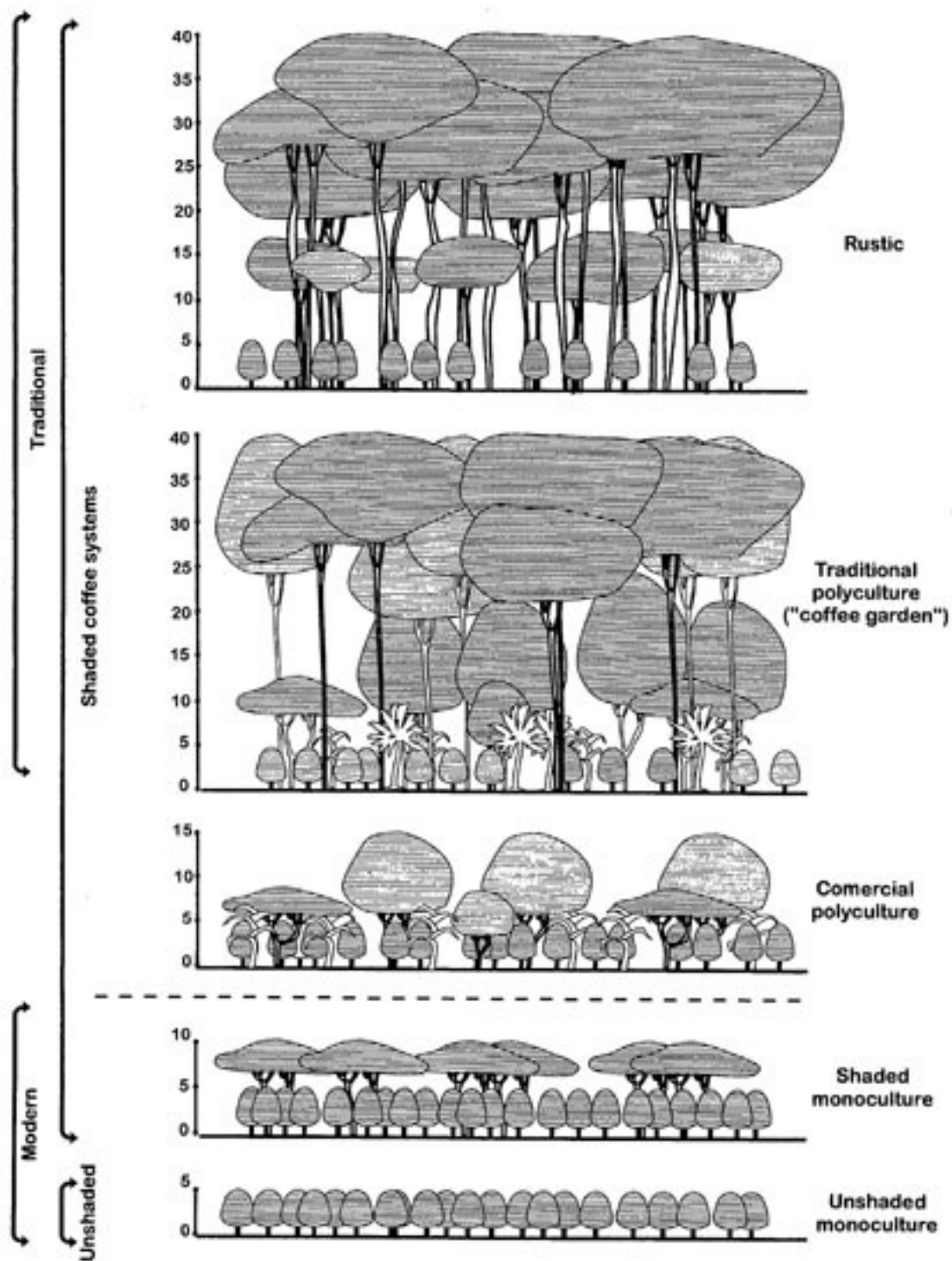


Figure 1.2.1. Types of coffee production systems. Figure from Moguel and Toledo (1999).

Deforestation

In many regions, particularly where land is cheap and plentiful, deforestation is still a significant result of the expansion of coffee production. In addition to direct conversion of forests to coffee farms, firewood must be supplied to the driers at coffee processing plants, putting further strain on local forest resources (Pelupessy 1997). Even clearing the forest understory to plant shade-grown coffee can have important negative impacts on forest-dependent species (Rappole et al. 2003a), and some believe that promotion of shade coffee by conservation, aid and development organizations, and a lack of sufficient oversight of shade certification criteria, has created perverse financial incentives for farmers to do exactly that (Rappole et al. 2003b).

In the Ivory Coast, about one million hectares were deforested for coffee production between 1960 and 1997 (Sendieu 1996 p. 13; cited in Pelupessy 1997 p. 28; ICO 2005e). Rappole et. al. (2003a) consider conversion of endangered Central American pine-oak forest to coffee farms to be an important threat to the endangered Golden-cheeked Warbler (*Dendroica chrysoparia*), a pine-oak obligate. O'Brien (2003) found a significant positive correlation between the price of Robusta coffee and the rate of deforestation in Indonesia's Bukit Barisan Selatan National Park, one of the last remaining habitats for the critically endangered Sumatran tiger.

According to Pelupessy (1997 p. 30), coffee production in Costa Rica has historically not been directly responsible for any significant amount of deforestation. For some this may be difficult to believe, given what is known about the role of coffee in the expansion of Costa Rica's agricultural frontier. The area planted in coffee in Costa Rica between those years of 1961 and 2000 for which data are available is highly negatively correlated with forest cover ($r = -0.564$, $N=36$, $p=0.000$) (data from UNFAO 2005; 1999; 2001). Coffee area expanded during this time period by only 36,000 hectares, while forest cover was reduced by nearly 1.7 million hectares. Thus, expansion of coffee production accounted for, at most, two to three percent of deforestation in Costa Rica during those years. The agricultural area in Costa Rica increased by nearly 1.5 million hectares, representing 88% of forest loss, but coffee actually decreased as a percentage of agricultural area during this time period – from 5.2 to 3.9% (all data from UNFAO 2005).

The data, therefore, support Pelupessy on this point, at least on a national scale. While the expansion of coffee production is correlated with forest cover loss, this is due to the expansion of agriculture in Costa Rica overall in the latter half of the 20th century, and other land use types, such as pasture (Hartshorn et al. 1982), make up the majority, by area, of uses replacing forest. Coffee has played an important role, however, at a local scale in some areas. For example, the deforestation of the southern *cantón* or county of Coto Brus over the last 50 years has largely been the result of the expansion of coffee area, with the encouragement of government settlement programs (Manger 1992).

Donald (2004) argues, without citing sources, that coffee expansion is directly responsible for “much” deforestation in Vietnam, where coffee expansion has exploded since the early 1990’s. In fact, the data do not support this assertion. Data from the UN Food and Agriculture Organization show that between 1990 and 2000, the years of the most significant coffee expansion in Vietnam, forest cover in Vietnam actually increased by 52,000 hectares (0.5%) (UNFAO 2001 p. 155), while the area dedicated to coffee growing increased by 415,000 hectares, or 671%.

During this time period, coffee area in Vietnam was not significantly correlated with forest area ($r=0.361$, $N=8$, $p=0.380$) (data from UNFAO 2005; 1999; 2001). It appears likely, therefore, that the expanded coffee area in Vietnam was converted from other agricultural uses rather than being carved out of forests, or was planted in areas defoliated during the Vietnam War (Wild 2004 p. 6). The expansion of forest area may be due to abandonment of other types of crops representing an area larger than the new area planted in coffee. More research on this point would be necessary before valid assertions could be made about the relationship of coffee to forest area in Vietnam.

There is probably significant local variation, however, with coffee expansion clearly accounting for important forest losses in certain regions, such as Coto Brus in Costa Rica. Looking at forest losses on a national scale also disguises the effects of coffee expansion on specific types of ecosystems. For example, in a study of LANDSAT data for Costa Rica between 1986 and 1991, Sánchez-Azofeifa (2001) found that the premontane moist forest life zone, which provides the most optimal conditions for coffee production (Holdridge 1967 p. 16; Boucher 1983), was the most severely depleted of the

life zones analyzed, with only 2% of primary forest remaining in this life zone. The same study found, however, that in the premontane rain forest life zone, which characterizes much of the local study area for this thesis (Hartshorn et al. 1982 p. 11) as well as many other coffee-growing areas in Costa Rica, 60% of forest cover remained. Roberts et al. (2000a) estimate that coffee plantations make up as much as 54% of the area that has replaced premontane and cloud forests in Mexico, Central America and Colombia.

Coffee farms also affect the structure of secondary forests that replace them when the farms are abandoned. Marcano-Vega et al. (2002) studied forest regeneration in abandoned coffee farms and pastures in Puerto Rico, and found that the dominance of coffee in the landscape had significant effects on the species composition of secondary forests that regenerated in both coffee and pasture, with trees commonly used for shade in coffee plantations dominating the secondary forests. Species composition changed more rapidly in regenerating pastures than in regenerating coffee farms. This appeared to be a result of the dominance of coffee plants and associated shade trees in the abandoned coffee farms, which competed with other secondary forest trees. In Puerto Rico, Thompson et al. (2002) were able to detect differences in the species composition of forest trees in regenerated forests that had previously been used for either selective logging or coffee production, some 40 to 60 years after abandonment.

Biodiversity

Agroforestry systems, such as coffee, may serve as refuges for wildlife in a landscape that is otherwise fragmented or degraded (Borrero & Ignacio 1986; Moguel & Toledo 1999; Perfecto et al. 1996; Perfecto et al. 1997; Komar 2000; Perfecto & Vandermeer 2002). For example, Puerto Rico has lost an estimated 99% of its forest cover in the 500 years since European colonization. Due in part, however, to canopy cover provided by shade coffee plantations, less than 12% of the native bird diversity was lost during this time period (Lugo 1988). In Costa Rica and Panama, the AMISCONDE Initiative of Conservation International and the Tropical Science Center has worked to encourage coffee production – primarily commercial polyculture or shaded monoculture – in the buffer communities surrounding the La Amistad Biosphere Reserve, with the belief that this will assist conservation efforts in the reserve (Young 2003).

Clearly, the level of structural diversity and agro-biodiversity in different production systems for the same product will have an effect on the capacity of those production systems to support higher levels of associated (i.e., non-agricultural) biodiversity. In Central America, the diversity of vertebrates has consistently been found to be higher in shaded coffee than in sun coffee (Moguel & Toledo 1999; Perfecto et al. 1996; Borrero & Ignacio 1986), with birds being the most frequently studied group. In Sulawesi, Indonesia, Siebert (2002) found bird diversity to be higher in rustic coffee than in shaded coffee monoculture.

Studies in El Salvador found a steady increase in bird diversity as canopy cover increases, and a high level of correlation between tree species diversity and bird diversity (Komar 2000; 2001). This last finding is supported by research in other regions (Perfecto et al. 1996). Factors such as tree basal area, emergent trees, canopy height, and the abundance of flowering or fruiting trees were less important than canopy cover and tree species diversity, at least for birds (Komar 2000; 2001).

Lindell et al. (2004) worked in Coto Brus in southern Costa Rica, where coffee is grown in a commercial polyculture where the “shade” consists primarily of *Musa spp.* and small (<7m) leguminous trees. They found a higher proportion of birds restricted to forest habitats (29.9% vs. 16.4%) than was found by Estrada et al. (Estrada et al. 1997; cited in Lindell et al. 2004) in coffee farms in Los Tuxtlas, Mexico, where coffee farms had shade cover consisting of forest trees over 15 m tall. Several species that Lindell et al. found restricted to forest were detected by Greenberg et al. (1997; cited in Lindell et al. 2004) in coffee plantations in Chiapas, Mexico that had a greater number of trees between 8-10 m tall than the Costa Rican sites.

A study in Asia indicated that the bird species most impacted by conversion from primary forest to agroforestry systems, including shade coffee, were large insectivores (Thiollay 1995). Another study, in Jamaica, indicated that it was insectivores and nectarivores that showed the most activity in shade coffee plantations (Johnson 2000). From these apparently conflicting results, it would appear that the relationship between various types of coffee production and insectivore populations, and the ability for coffee

farms of various types to act as corridors for sensitive forest species, varies between localities, and needs to be further examined.

Petit and Petit (2003) compared mid-elevation shaded coffee with pasture, fallow pasture, Caribbean pine plantations, residential areas, sugar cane, rice, gallery forest, lowland forest fragments, gallery forest, extensive lowland forest and extensive premontane forest in central Panama, with respect to their value as habitat to birds that are vulnerable to disturbance. They found that pasture and all crops except coffee were devoid of forest specialists, while coffee supported primarily forest generalist and species associated with open woods and scrubland. In terms of importance in the conservation of the most vulnerable species, they found that coffee was the most important of all non-forest habitats, with an “importance score” double that of the next-ranked habitat, gallery forest. The coffee in this study appears to have been traditional polyculture.

In the Colombian Andes, Numa et al. (2005) found that bat species richness was not significantly different between shaded coffee farms and a commercial polyculture similar to that studied by Lindell et al. (2004). Both types of coffee had significantly lower species richness than nearby forest fragments, but the species composition in the shaded coffee was more similar to the forest than was the commercial polyculture, while the commercial polyculture showed higher β diversity than the shade coffee. In Veracruz, Mexico, Pineda et al. (2004) found that bat species richness and composition was nearly the same in cloud forest and traditional polyculture coffee plantations.

Arthropod diversity has also consistently been found to be higher in shade plantations than in technified plantations (Nestel et al. 1993; Perfecto & Vandermeer 1996; Perfecto et al. 1997; Moguel & Toledo 1999; Roberts et al. 2000b; Rojas et al. 2001; Perfecto & Vandermeer 2002). In Chiapas, Mexico, Perfecto et al. (2003) found that ant and butterfly diversity decreased along a gradient from forest to increasingly intensified coffee farms, with butterflies appearing to be more sensitive to the changes. In Sulawesi, Indonesia, Klein (2004) found that Chalcid wasps did not nest in traps outside of forest or rustic coffee farms, while Braconid wasps were found more often in intensively managed systems, and other families showed no differences across habitat

types. Species richness of social bees decreased with land use intensity, while species richness of solitary bees increased.

Diversity of Coleoptera (beetles) has been found to increase with tree species diversity, up to at least 10 species of trees per hectare (Nestel et al. 1993). Research in Veracruz, Mexico found no significant differences in the diversity of Scarabid and Silphid beetles between disturbed tropical montane cloud forest and coffee with either monospecific or polyspecific shade cover (Arellano et al. 2005). In Veracruz, Mexico, Pineda et al. (2004) found a higher species richness of corproncrophagous beetles in traditional polyculture coffee than in tropical montane cloud forest.

Bandeira et al. (2005) studied tree species diversity on rustic coffee plantations in southern Mexico. They concluded that, while individual farms did not contain enough forest tree species diversity to contribute significantly to biodiversity protection, the high variability between farms, and the resulting β diversity, made this production system an important component of tree diversity conservation in an agricultural landscape. This study found 27 wild species of trees and 12 cultivated species, which is substantially more species than are found in many other types of agricultural systems. Siebert (2002) compared diversity of trees, epiphytes and lianas in rustic and shaded monoculture coffee, and not surprisingly found diversity of all three to be higher in the rustic coffee, but unfortunately did not compare either to forest.

Of course, despite shade coffee's benefits for biodiversity in comparison to sun coffee, even rustic coffee compares poorly to native forest. Rappole et al. (2003a) cite numerous findings of reduced biodiversity in shade coffee compared to forest, and point out that discussions of "biodiversity" can be deceptive when other variables are not considered, i.e., "[a]n agricultural site in which 30 forest bird species have been replaced by 30 open-country bird species can have the same avian diversity as a forest site." Forest-dependent specialist species are the most likely to disappear after conversion of forest to any type of coffee production.

For example, in a traditional polyculture in Chiapas, ants showed decreased diversity in coffee as compared to primary forest, and diversity decreased further with distance from the forest. A shaded monoculture was, of course, less diverse still

(Armbrecht & Perfecto 2003). A study of army ants in Panama found that there was no significant difference in army ant populations between primary forest and shade coffee adjacent to primary forest (Roberts et al. 2000b), where the type of shade was remnant primary forest trees (pers. obs. 2003), but populations declined significantly with distance from forest. Army ants are considered top predators of the arthropod world, and are sensitive to habitat destruction (Lovejoy et al. 1986; Harper 1989; Roberts et al. 2000b).

Lindell and Smith (2003) gathered information regarding bird nesting activity in pasture, abandoned sun coffee, and forest in the *cantón* of Coto Brus in southern Costa Rica, near the local area studied in this thesis. They found that the family distributions of birds nesting in pasture and abandoned coffee were significantly different from the family distributions of birds found nesting in forest, but were not significantly different between pasture and abandoned coffee. Overall, they found that coffee and pasture were “functionally quite similar” for nesting birds. They also found, however, two species of forest-dependent birds, the Chestnut-capped Brush-finch (*Buarremon brunneinucha*), and the White-breasted Wood-wren, (*Henicorhina leucostica*), nesting in coffee but not in pasture.

Certain groups of birds have been found to be highly sensitive to the conversion of forest to agricultural land uses, including coffee. During point counts in Coto Brus, Lindell et al. (2004) detected only one trogon (Trogonidae), and two antbirds (Formicariidae) in agricultural areas, compared to 80 and 543 detections, respectively, in forest areas. Lindell and Smith (2003) also found that, in the same region, antbirds were very unlikely to nest in coffee, even when the farms were adjacent to extensive tracts of primary forest.

In Sumatra, Gillison et al. (2004) found that plant species diversity increased steadily from primary and late secondary forests through increasingly more structurally complex coffee farming systems. Hietz (2005) found reduced species richness of vascular epiphytes in commercial coffee polycultures compared to forests. Although species richness in traditional polycultures was similar to that found in forests, community heterogeneity was greater in forest. In Veracruz, Mexico, Pineda et al. (2005) found a reduction of 20% in species richness of frogs from tropical montane cloud

forest to traditional polyculture coffee, and only half of the species found in forest were also found in coffee.

Habitat connectivity

Patches of forest habitat in the tropics have become increasingly isolated over the past 20 years, and it is important for conservation goals to consider the matrix surrounding forest fragments (Defries et al. 2005; Jules & Shahani 2003). One ecological function that coffee farms may provide is to act as corridors between forest fragments (Perfecto & Vandermeer 1996; Roberts et al. 2000b; Sherry 2000). Additionally, coffee may be incorporated at a low density into a crop rotation system involving various stages of successional forest with its associated biodiversity, where coffee is used as a means to make these ecologically important rotations more economically productive (Darryl Cole-Christiansen, pers. comm. 2003)

In the Lampung province of Sumatra, Indonesia, most of the nearly 20% of the land area that is protected are in small fragments. A significant part of the agricultural matrix between these fragments is made up of agroforestry systems, dominated by rubber but also including coffee. These lands appear to provide corridors for endangered Sumatran tigers, but because of the fact that they are used by both humans and tigers, they also serve as “hot spots” for encounters between the two species (Nyhus & Tilson 2004). Woodroffe and Ginsburg (1998; cited in Nyhus & Tilson 2004) found that conflict with humans in such areas on the edges of reserves is a significant cause of mortality for large carnivores. Thus, in the case of animals that can be dangerous to humans, the very services that agroforestry systems provide in terms of habitat connectivity may also increase their risk of mortality from conflict with people.

For birds on a global scale, the factors most affecting the risk of extinction due to habitat destruction have been shown to be small body size and habitat specialization (Owens & Bennett 2000). Insectivorous birds, particularly understory insectivores, are one of the guilds most affected by habitat fragmentation in the Neotropics (Stouffer & Bierregaard 1995; Stratford & Stouffer 1999; Sekercioglu et al. 2002). Studies of the responses of these birds to forest fragmentation indicate that food availability in fragments may not be, as previously believed, a limiting factor for population survival

(Burke & Nol 1998; Zanette et al. 2000; Sekercioglu et al. 2002). Rather, it appears that use of forest fragments by insectivorous birds is limited by a species' ability to disperse across the intervening, human-modified landscape (Sekercioglu 2002; Sekercioglu et al. 2002). In a study of seven species of understory insectivorous birds in the Brazilian Amazon, Antongiovanni and Metzger (2005) found that the matrix habitat was important in determining whether sensitive species would be found in forest fragments. Thus, the matrix habitat surrounding and connecting forest fragments appears to be important in facilitating the continued survival of understory insectivores in fragmented landscapes.

Birds that follow army ant swarms (many of which are understory insectivores) are among the most sensitive to habitat destruction and fragmentation, and are unwilling to cross open areas (Stouffer & Bierregaard 1995; Holmes 1996; Mason 1996; Stouffer 1998; Renjifo 1999). Roberts et. al. (2000a) found army ants and ant-following birds on shaded coffee plantations adjacent to primary forest in Panama, though not on plantations distant from primary forest, indicating that shaded coffee farms, while in themselves not suitable habitat for army ants and ant followers, may provide connectivity between forest patches for these groups.

Numa et al. (2005) studied elements of habitat connectivity provided by different types of Colombian coffee farms in which small forest remnants were embedded. Their results indicated that both shaded and commercial polyculture coffee provided habitat connectivity for bats in the region, but the shaded coffee appeared to be of higher importance in this respect.

Summary

Expansion of area for coffee production may be a factor in local deforestation rates. Although deforestation for coffee production probably does not account for a significant portion of total deforestation, the suitability of coffee for production in biodiversity "hot spots" means that it may be a locally important factor in threatening certain imperiled ecosystems. Coffee farms, even those classifiable as "rustic," are species-poor in comparison to native forest, and many sensitive species are not found in coffee.

In comparison to other types of agricultural land use, however, coffee appears to have important value in providing wildlife habitat in countryside landscapes, and in providing some measure of connectivity between forest reserves. This is true even, in certain cases, of shaded monoculture coffee. Thus, from a conservation standpoint, coffee farms are a desirable component of tropical agricultural landscapes, and their conversion to other uses is likely to be cause for concern to those interested in tropical biodiversity conservation.

3. Anatomy of a crisis

Dynamics of the international coffee market

The beverage known as coffee is an infusion of the dried, roasted and ground seeds of plants of the genus *Coffea*, in the family Rubiaceae. Nearly all the world's coffee is produced by the two species *C. arabica* and *C. canephora*, which produce Arabica and Robusta coffees, respectively. Coffee grows best in tropical or subtropical regions, between 800 and 1500m above sea level, where temperatures remain between 23° and 28°C for most of the year and annual rainfall is between 1,500 to 2,000mm (Boucher 1983; Coste 2001).

Coffee trees will begin to bear in about 3 years (Boucher 1983), take 6-8 years to reach maximum production (Pelupessy 1993 p. 25), and can remain productive for up to 40 years (Aguilar 1992 p. 10). Thus, a mature coffee plantation represents a substantial financial investment that is not easily abandoned or exchanged for another product (Kutschbach 1994a p. 16). Coffee is often grown in steep areas, where there are few alternative uses for the land (Kutschbach 1994b p. 84). These constraints mean that supply and demand are rarely, if ever, in equilibrium (Aguilar 1992 p. 10), resulting in dramatic fluctuations in export prices (see Figure 1.3.1).

The international coffee chain involves, in most cases, 6 actors. The farmer sells the fresh cherries to a processor, who removes the pulp and a thin membrane (known as the parchment) surrounding the bean, dries the beans and sells them to an exporter. The beans are next sold to a roaster, then to a retailer, and finally to the consumer. Because

roasted and ground coffee rapidly loses quality, those steps in the chain that add value to the raw material typically take place, by necessity, in the consuming country.

Four primary types of coffee are recognized, and these, from lowest to highest quality, are: Robustas, unwashed Arabicas, and the two “washed” Arabicas, classified as Other Milds and Colombian Milds. Whether a coffee is classified as “washed” or “unwashed” is determined by the method used to process the whole cherries into green coffee (Aguilar 1992 p. 10), with the method used to produce “washed” Arabicas referred to as the “wet method.” Within the category of the other milds, the coffees classified as “strictly hard bean,” grown above 1200 m, are considered the highest quality (Varangis et al. 2003; cited in Rappole et al. 2003b). Historically, the price difference between Robusta and Arabica has been around 10%, rising as high as 30% (VNKT 1987; cited in Pelupessy & Tilburg 1994 p. 244), but currently the price of Arabica is more than double that for Robusta (Osorio 2005a).

For coffee processed by the “wet” method, the first steps in the processing of the cherries tend to be heavily centralized, as they must be performed a very short time after harvesting (Pelupessy 1997). This severely limits the options available to farmers, who must rely on processing plants or collecting stations very close to their farms. In more remote regions, such as in Guatemala and the Mexican state of Chiapas, farmers sell their coffee to middlemen called *coyotes*, usually at steeply reduced prices, who transport the cherries to the processor, known in Latin America as a *beneficio*. The *coyotes* often provide credit to the farmers at high interest rates, to be paid off with the money from their harvests, keeping the farmers in an unending circle of indebtedness (Dicum & Luttinger 1999).

Other Central American farmers take their coffee directly to either one of about 400 *beneficios* in the region (Pelupessy & Tilburg 1994 p. 251), or, as in Costa Rica, to one of thousands of collecting stations, called *recibidores*, located within walking distance of the farms and operated by the *beneficios*. Regulations governing the prices paid by *beneficios* to farmers vary widely from country to country, with *beneficios* in some countries required to pass on a specified percentage of the export price (Pelupessy 1997 p. 26), and others not subject to any regulation at all. In the early 1990’s,

approximately 25% of Central America's 200,000 farmers, owning 15% of coffee land and producing 14% of Central America's coffee, belonged to farmer-owned processing cooperatives (Pelupessy & Tilburg 1994 p. 252).

In the early 1990's, least 20 million families worldwide relied on the production of coffee for survival (Pelupessy 1993 p. 33). In certain years in the late 1980's, coffee was second only to oil in its share of the global commodity market (Portillo 1993), but that share has declined substantially since then (calculated from UNFAO 2005). During the decade ending in 2002, green coffee accounted for an annual average of \$9.4 billion in international trade (UNFAO 2005). Approximately 90% of coffee is imported as dried, unroasted beans (Pelupessy 1993 p. 28), referred to in the industry as "green coffee" or, in Spanish, *café oro* or "golden coffee." In 2003, 5.4 million metric tons of green coffee were traded worldwide, valued at approximately \$7.6 billion (ICO 2005b).

Figure 1.3.2 shows the international trade in green coffee from 1961 to 2003. World exports by weight have nearly doubled during this 32-year period. Over the last 100 years, world consumption has grown at a more or less steady rate of 1.8% per year, interrupted only by the two world wars (Daviron 1994 p. 38). Between 1961 and 2001, growth in coffee consumption slightly surpassed global population growth, averaging 1.9% per year, while the population grew at 1.7% per year (UNFAO 2005). In the early 1990's, roughly 20% of coffee produced was consumed in the producing countries (Pelupessy 1993 p. 21).

Between 60-90% of the value of a pound of coffee is added in the consuming country (Pelupessy 1997 p. 9). This includes roasting, grinding, packaging and marketing. Stiff tariffs on value-added coffee products in producing nations pose a major barrier, hindering producing countries from expanding into these areas. Globally, coffee roasting is also dominated by a very small number of players. Five roasters - Kraft, Nestlé, Procter & Gamble, Sara Lee, and the German roaster Tchibo – together control half of the world's coffee beans (Gresser & Tickell 2002 p. 2). Buyers for large roasters such as these often receive bonuses for purchasing cheap coffee (Dennis Macray,^{*} pers. comm. 2004). With both exports and sales of roasted coffee controlled by these

^{*} Manager, Business Practices, Corporate Social Responsibility, Starbucks Coffee Company

international near-monopolies, a country such as Costa Rica, which produces only a few percent of total world supply, is in a comparatively weak bargaining position.

Each of the four types of coffee (Robusta and the three types of Arabicas) represents about a quarter of the world supply (Pelupessy 1997 p. 8). In 2002, Arabica made up 68% of the world coffee market, with Other Milds making up 35% of the world trade in Arabica coffee (Fernández et al. 2002; UNFAO 2005). Typically, each country only grows one type of coffee (Aguilar 1992 p. 24), although fourteen countries produce both (ICO 2005b). Although prices can be more than double for Arabicas (Osorio 2005a), lower production costs mean that Robustas can give higher profits (Pelupessy 1993 p. 20). Costa Rica is one of 22 countries, 16 of which are in Latin America and the Caribbean, that produce washed Other Milds (ICO 2005b), and in 2002 produced 10% of world supply of this type of coffee (Fernández et al. 2002). In the early 1990's, Central American countries together accounted for 25% of production of Other Milds (Pelupessy & Tilburg 1994 p. 244).

Arabica coffee is traded on the Coffee, Sugar and Cocoa exchange in New York City, and Robusta on the London Coffee Terminal Market. Speculation in the futures markets on both these exchanges tends to increase price volatility, and producing countries themselves have been known to buy and sell futures to influence prices (Pelupessy 1993 p. 33; 1997 p. 9). In the early 1990's, approximately 50 coffee trading firms controlled the world markets, with the largest eight controlling 50% (Pelupessy 1993 p. 42).

The history of coffee growing can be divided into two distinct periods (Daviron 1994 p. 42). During the earlier period, countries increased production by expanding the amount of land used to grow coffee. In the 1960's, due to the dwindling availability of cheap land, the strategy began to change. Producers sought to increase production using technological advancements such as new, high-yielding coffee varieties, reduced shade cover, higher planting densities, and increased agrochemical inputs. This process is referred to as "technification" or "modernization" of holdings. Costa Rica and Kenya were the first countries to embrace this new model, followed quickly by others (Daviron 1994 p. 45). In essence, the inputs required for coffee production – as with any

agricultural commodity – can be broken down into three categories: land, labor, and technology. The relative availability and cost of each input in a given region will determine the type of system used there (Kutschbach 1994b p. 87).

Technified systems, while increasing income during good years, also make farmers more vulnerable to market risks (Kutschbach 1994a p. 19). Over the long term, producers with the lowest costs of production will always have the highest profits (Daviron 1994 p. 31), while medium-intensity farming appears to have the most flexibility in responding to price swings (Kutschbach 1994c p. 233), and overall financial risk is lower on more diversified, less technologically intensive coffee farms (Reeves & Lilieholm 1993; Gobbi 2000; Ramirez & Sosa 2000). Banks in some regions, however, may tie access to credit to technology use (Perfecto et al. 1996; Rice 1999), putting more traditional farmers at a competitive disadvantage.

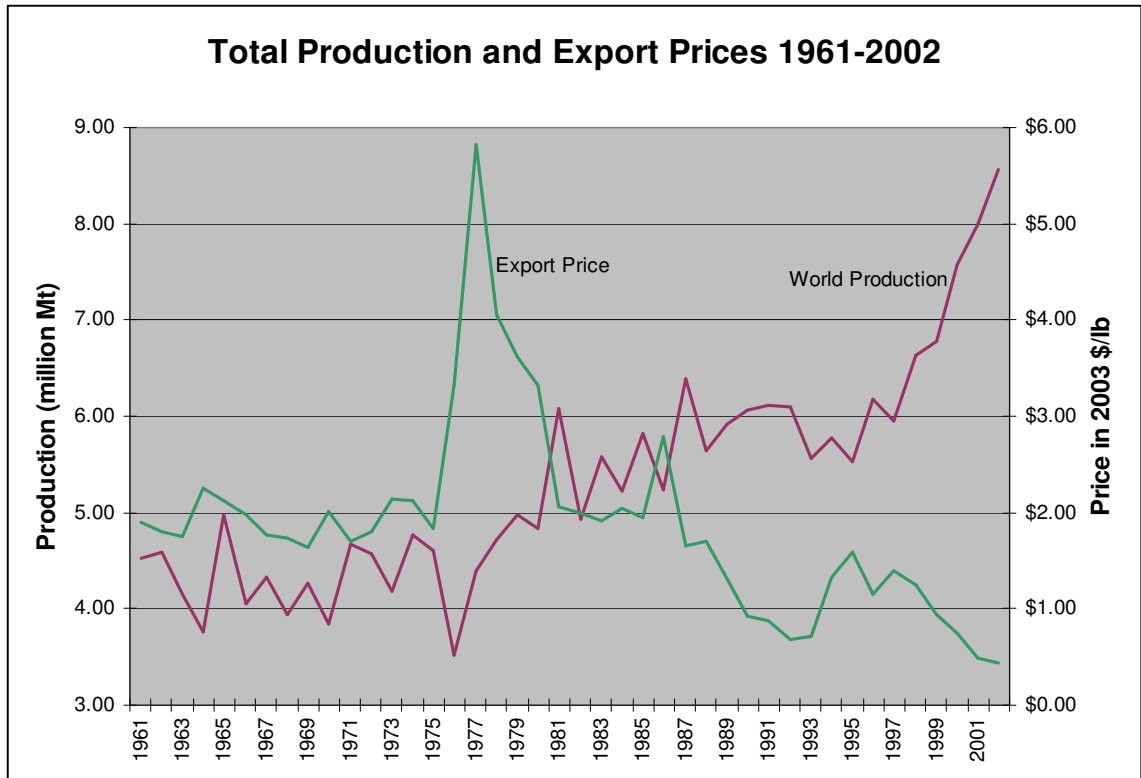


Figure 1.3.1. Total world production of coffee (all types) plotted with average world export prices 1961-2002. Export prices are in constant 2003 dollars. Data from UNFAO (2005). Inflation adjustments for all figures are calculated from U.S. Department of Labor (2004).

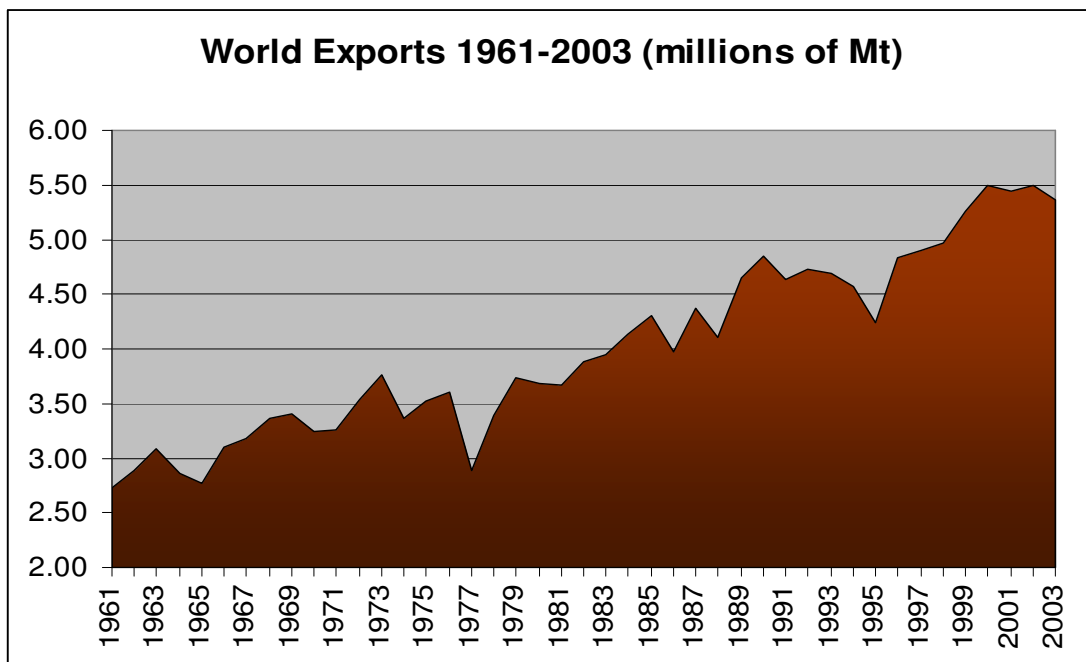


Figure 1.3.2. Total world coffee trade in millions of metric tons, 1961-2003. Data from ICO (2005b) and UNFAO (2005).

Coffee in Costa Rica

In 2003, Costa Rica was a country of just over 4 million people spread over 51,100 square kilometers (World Bank Group 2005b). Until the mid-1980s, Costa Rica had the highest per capita GDP of any Central American nation, only recently losing that place to Panama (Karnes 2001). Costa Rica scores well in most development indicators with, in 2003, a literacy rate of 96%, 90% of primary-aged children enrolled in school, 89% of children immunized against measles, an infant mortality rate of eight children per thousand, life expectancy of 79 years, and population growth rate of 1.6%. Ninety-seven percent of Costa Ricans have access to potable water, and 92% have access to sanitation (World Bank Group 2005b). Costa Rica scores better than neighboring Panama in all these areas except population growth and primary enrollment, and better than Latin America as a whole in all areas except primary enrollment, immunization rates and population growth. Costa Rica's mean educational level in 2000 was 7.5 years, and 46% of the population had a secondary education or higher (INEC 2001).

Like most developing nations, Costa Rica is rapidly urbanizing. At the time of the 1973 population census (DGEC 1974), 41% of the population lived in areas defined by the census as urban, a number that had risen to 59% by 2000 (INEC 2001). By 2003, Costa Rica had seven telephones and four personal computers for every twenty people, compared to eight telephones and one computer per twenty people for both Panama and Latin America as a whole. In 2000, Costa Rica released 1.5 metric tons of carbon per capita annually, compared to 2.2 for Panama and 2.7 for all of Latin America (World Bank Group 2005b).

The Costa Rican economy has always relied heavily upon exports, although that reliance appears to be decreasing. In 2004, exports accounted for 45.6% of GDP, down from 51.6% in 1999 (World Bank Group 2005b). In 2000, imports surpassed exports for the first time, and Costa Rica maintained a negative trade balance through at least 2002 (World Bank Group 2003). The tourism industry is also an important part of the economy, with retail sales, restaurants and hotels accounting for 17.9% of GDP in 2001 (SEPSA 2002). In 2003, Costa Rica's external debt was \$5.8 billion, or \$1,450 per capita (World Bank Group 2005b).

Agriculture, traditionally a main component of Costa Rica's GDP, has been gradually declining in relative importance, from 27.7% of GDP in 1982 (World Bank Group 2003), to 11.5% in 1995 (SEPSA 2002 p. 3) and 8.7% in 2004 (World Bank Group 2005b). Until recently, Costa Rica's most important agricultural export had been coffee. In 1984, coffee represented 27.6% (\$491 million^{*}) of Costa Rican exports, bananas 25.9% (\$462 million), and manufactured goods 26.4% (\$471 million). In 2003, they represented 3.2% (\$194 million), 9.0% (\$553 million), and 77.0% (\$4.7 billion), respectively (World Bank Group 2005a).

Coffee production took hold in Costa Rica in the early half of the 19th century, decades before it became established in the rest of Central America (Williams 1994; cited in Rice 1999). By 1900, the coffee industry had driven population growth and the establishment of several urban centers. The absence of a large indigenous population created a chronic labor shortage in the coffee sector, a shortage that has never been fully resolved. Coffee represented nearly 100% of Costa Rican exports until 1900, when the country began to export bananas, and remained at around 50% until the 1930's (Winson 1989 pp. 10-16). World War II dealt a serious blow to the Costa Rican coffee industry, further reducing its importance to the nation's economy (Winson 1989 p. 41) and increasing the need to diversify.

Throughout most of the second half of the 20th century, coffee was a motor of upward mobility for many in Costa Rica, increasing the wealth and consumption levels of most coffee growers (Hilje et al. 1994 p. 204). From the 1950s to 1980s, the social organization of coffee production in Costa Rica underwent a transformation, corresponding to the rise in technology use and the advent of farmer-owned cooperatives for processing and exporting coffee. Although state policies at the end of the 1950s aimed to encourage diversification and industrialization, the country maintained a dependency on agriculture, and coffee in particular, throughout this period (Vorst 1986).

At the end of the 1980's, Central America accounted for 12% of world coffee production, with each country producing no more than 3% of world supply (Pelupessy 1993 p. 13), and Costa Rica producing about 2%. Figure 1.3.3 shows Costa Rican

^{*} In 2003 dollars

production as a percent of world production of all types of coffee from 1961-2003. Costa Rica's share of world production peaked in 1993 at 2.82%, and has declined fairly steadily since, to 1.6% in 2003.

Despite this small portion of the world market, in the 1980s Costa Rica was one of four main centers of supply-side power in the International Coffee Organization, representing the producers of the Other Milds group of washed Arabicas (Aguilar 1992 p. 26), of which it currently produces about 10% of world supply (Fernández et al. 2002 Anexo 5). Germany and the United States are the two largest importers of Costa Rican coffee, together accounting for 56% of exports in 2002 (Fernández et al. 2002 p. 30).

As of 1984, 30,706 km² of Costa Rica was farmland, or 60% of the total land area. About 900 km² of this (2.9%) was planted in coffee, 16,500 km² (53.7%) was pasture, and 14,600 km² (47.5%) was planted with other permanent crops, particularly bananas and sugar (DGEC 1987). Coffee area appears to have reached its peak in Costa Rica in 1989, at 115,000 hectares, after which it declined to 101,000 hectares in 1993-94, before increasing again to 113,000 hectares in 2001 (SEPSA 2002 p. 16; Pelupessy 1997 p. 13). In Costa Rica, ripe coffee cherries are measured in *fanegas*, one of which equals 400 liters, and *cajuelas*, twenty of which equals one *fanega*. Typically, one *fanega* of coffee cherries will yield about 100 pounds of green coffee (ICAFE 1993).

In 2004, there were 95 *beneficios* in Costa Rica, 22 of which were farmer-owned cooperatives (Fernández & Alvarez 2004). In the early 1990's, farmers who belonged to cooperatives received 67-69% of the export price of their coffee (Pelupessy & Tilburg 1994 p. 253). In 2002, there were 34 roasters and 56 exporters in Costa Rica (Brenes 2002). Most cooperative coffee was marketed directly by FEDECOOP, the Costa Rican Association of Coffee Cooperatives, circumventing exporters (Winson 1989 p. 108). In 2001-02, 70,523 farmers and 303,766 paid workers were involved in the harvest (Brenes 2002).

Technology and input use in Costa Rican coffee production is among the highest in the world (Perfecto et al. 1996). Adoption of technology came early, when in the early 1950's the Costa Rican government capped profits from fertilizer sales, lifted duties on imported fertilizers, and began to produce lime. In 1954 the Banco Anglo Costarricense

initiated a program to renovate 20% of the country's coffee farms that were larger than 1.5 hectares. Cheap, easy credit and high labor costs also encouraged farmers to focus on inputs and technology (Winson 1989 p. 101-104).

By 1963, a third of Costa Rica's coffee land was planted with new, high-yielding varieties (Winson 1989 p. 115). In 1978, the U.S. Agency for International Development (USAID) started a program, based in Costa Rica, to further encourage the adoption of new technologies in coffee production (Hernandez Navarro 1995; cited in Rice 1999). The scarcity of appropriate land for coffee production during the last few decades, and the high export prices of the late 1970's, encouraged monocultures in the most optimal coffee-growing regions. Throughout the 1970's and 1980's, the Ministry of Agriculture extension agencies promoted new technologies and coffee varieties, and the National Bank gave preferential interest rates for technification and renovation of coffee farms (Vorst 1986).

By the early 1990's, an estimated 40% of Costa Rica's coffee-growing areas were "technified," representing the most intensive form of coffee production, while only 10% was considered "traditional" production. This represented the second highest level of technification in northern Latin America - after Colombia, with 69% of its coffee area technified (Rice 1999).

As a result of the widespread incorporation of technology, Costa Rica has the highest coffee yields in Central America, where average yields in 1994 were around 800 kg of green coffee per hectare, and as low as 500 kg/ha in Nicaragua (Pelupessy & Tilburg 1994 p. 251). From 1964 to 1993, average yields in Costa Rica more than tripled, from 561 kg/ha to 1585 kg/ha. During the same period, average yields worldwide went from 384 kg/ha to 546 kg/ha, an increase of 42%. By 2002, however, worldwide yields had reached 832 kg/ha, a doubling over 1964 levels (yields calculated from UNFAO 2005; ICAFE 2003). Some Costa Rican farmers can achieve yields of up to 70 *fanegas*, or 3,175 kg, per hectare (Murillo 1996). Yields for farmers who belong to cooperatives is, on average, 22% lower than for farmers who sell to the private sector (Pelupessy & Tilburg 1994 p. 252). Figure 1.3.4 compares average yields for Costa Rica and the world from 1961 to 2003.

The Costa Rican Institute of Coffee is responsible for collecting taxes, establishing rules for coffee producers and processors, and providing technical and price information. When prices are above a pre-determined level, a tariff must be paid to the National Coffee Stabilization Fund (FONECAFE), which is used to compensate growers and processors when prices fall below costs of production. Processors' and exporters' profits are fixed at specific percentages, in an attempt to improve equity in the multi-tiered coffee export system (Pelupessy 1997 p. 26). For example, *beneficios*' profits were at 12% of the sale price from 1933 until at least the late 1980's (Winson 1989 p. 22). Enforcement of these caps appears to be strict, and the ICAFE collects and publishes detailed data about the prices received and paid by *beneficios* (pers. obs. 2003).

While most coffee plantations in Latin America occupy 5-30 hectares of land (Pelupessy 1993 p. 23), the average size of a Costa Rican coffee farm in 1984 was 2.6 hectares (Censo Agropecuario 1984). Because of the small average size of Costa Rican coffee farms, and the large number of farmers involved in coffee production, many writers have spoken of coffee as being a "democratizing" influence on the Costa Rican economy and culture. Even so, according to some analyses, land distribution in Costa Rica is the most unequal in Central America, if all types of land use are taken into account (Winson 1989 p. 96), although this could lend support to an argument that, compared to other products, coffee production is one of the more democratic sectors of Costa Rican agriculture.

The historian Lowell Gudmundson argues that the "democratizing" influence is a myth, and that coffee has in fact served to consolidate power and influence in Costa Rica (Mora 2001a). Some have pointed out that the owners of many of the country's "small" coffee farms in fact belong to a few extended families (Stone 1976; cited in Boucher 1983). Other authors have argued convincingly that the coffee "elite" in Costa Rica draw their power not from land ownership, as in other coffee-dependent countries, but from the control of processing, financing and exportation (Cardoso 1973; cited in Vorst 1986). Even so, the influence of the coffee elite appears to have peaked in the 1920's (Winson 1989 p. 38), before the coffee crisis of the Great Depression.

Democratic or not, there are clearly many structural inequities in the Costa Rican coffee production chain. While more than 90% of farms occupy less than five hectares (Pelupessy 1997 p. 14), together these small farms make up only 40% of the total coffee-growing area in Costa Rica (Pelupessy 1993 p. 24). This is, however, still higher than the Central American average, where small farmers own 27% of land area and produce 21% of the coffee (Pelupessy & Tilburg 1994 p. 251). Small farmers in Costa Rica can afford fewer inputs (Winson 1989 p. 115), and thus have lower yields than large farmers. For example, in the 1991-92 harvest, farms with less than 5 hectares of land produced the equivalent of 1,300 kg of green coffee per hectare, while those with more than 5 hectares produced close to 2,000 kg per hectare (ICAFE 1993 p. 67). Almost 93% of Costa Rican farmers harvest less than a total of 4,500 kg of coffee per year, and together they account for only 45% of Costa Rica's coffee (Brenes 2002).

Small farms are also the least likely to incorporate technology, and have the highest costs of production per pound if they do use a technology "package." Small-scale producers often can't take advantage of government renovation subsidies, because they cannot afford to wait for new varieties to come into production (Vorst 1986). The ICAFE calculated in 2002 that the average costs of production for a farmer using the recommended "technology package" and using only paid labor was \$86.07 per *fanega* (Portilla R. & Araya M. 2002 p. 7), however many farmers are able to reduce costs of production by using family labor and reducing inputs. Three studies carried out between 1999 and 2002 estimated production costs in Costa Rica at between \$0.77-\$1.00 per pound, the highest in Central America (Varangis et al. 2003 p. 20).

Small-scale farmers in Costa Rica bring their harvests to one of thousands of collecting stations or *recibidores* around the countryside, each owned and operated by a processor or *beneficio*. Rather than being paid for the coffee on the spot, Costa Rican producers sell their coffee on consignment through the *beneficio*, receiving payment only when the green coffee has been sold. Thus, a farmer may not receive the final payment for his harvest, delivered in October or November, until July or August of the following year, in effect providing an interest-free loan to the *beneficio* for up to a year (Pelupessy 1997 p. 24). This applies whether the *beneficio* is a cooperative or a private enterprise, and results in coffee farmers bearing most of the risk of the international market (Vorst

1986), while having little direct control over the variables affecting that risk (Pelupessy 1997 p. 24). Nevertheless, this does guarantee that the farmers receive a fixed share of the real export price of their coffee, without relying on speculation at the time of harvest.

Beneficios pay farmers based on the exchange rate at the time of harvest, while they sell the processed coffee at the rate in effect several months later. With the *colón* being devalued at upwards of 20% per year, this means that farmers receive substantially fewer *colones*, at a time when those *colones* are worth less, than the *beneficio* receives for selling their product. *Beneficios* are also required by law to sell a certain portion of their coffee (usually 10-15%) to the domestic market at a sharply discounted rate (Anonymous 1992b). This discount, which in 2003 resulted in a \$5.2 million loss to farmers (an average of \$72 per farmer) and \$2.3 million to processors (calculated from ICAFE 2003), is in effect a subsidy paid by Costa Rican coffee producers to the country's coffee drinkers.

The introduction and wide incorporation of technology has resulted in making much of the employment in coffee production seasonal or temporary, and reduced the total labor needed overall while increasing labor needs during the harvest (Hidalgo 1983; cited in Vorst 1986). For example, herbicide use reduces the labor needed for weed control by 75%, and use of fertilizers and fungicides can triple yields (Vorst 1986).

As a result, permanent employees only account for about one fifth of the harvest labor in Costa Rica: the others come from other sectors, the unemployed, or other geographical regions (Vorst 1986). According to studies by the Migrant Labor Division of the Costa Rican Employment Ministry, 13% of the country's coffee pickers are Panamanian Indians and 44% are Nicaraguans (Wa-chong 2001). Many coffee-growing families travel elsewhere to pick coffee after their own has been harvested. At least until the late 1980's, coffee workers did not have the right to strike because coffee production was considered a "national interest," and workers did not have representation in the ICAFE (Vorst 1986).

Figures

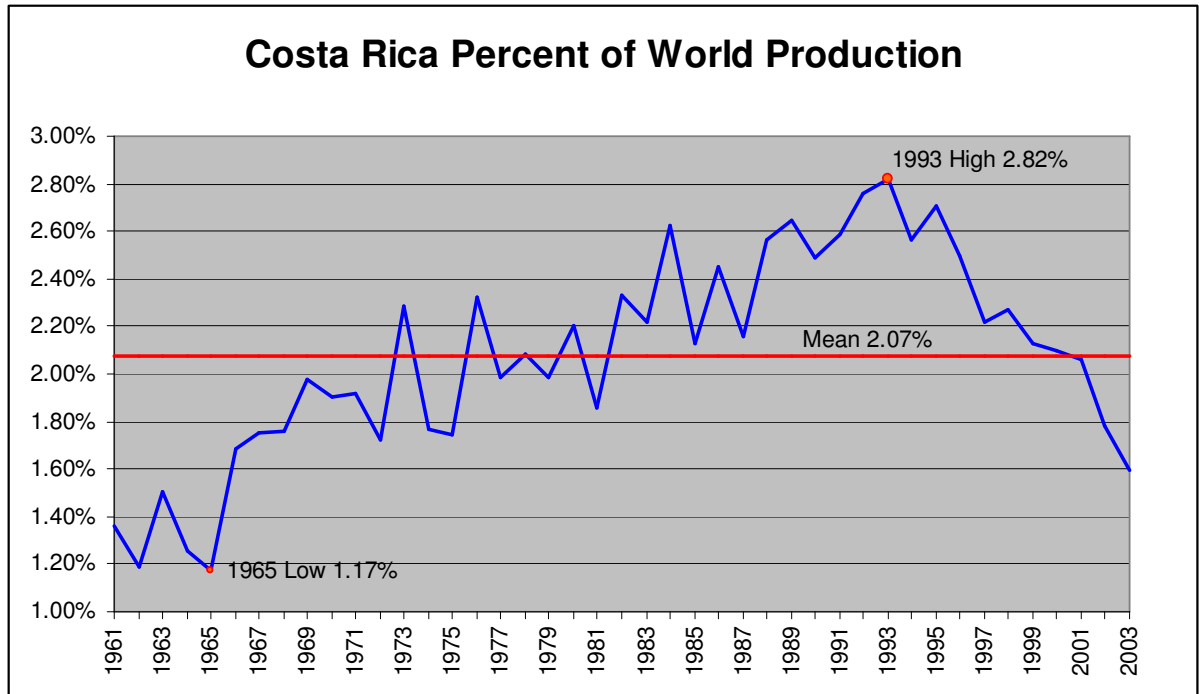


Figure 1.3.3. Costa Rican production as a percentage of world production. Data from Fernández et al. (2002) and UNFAO (2005).

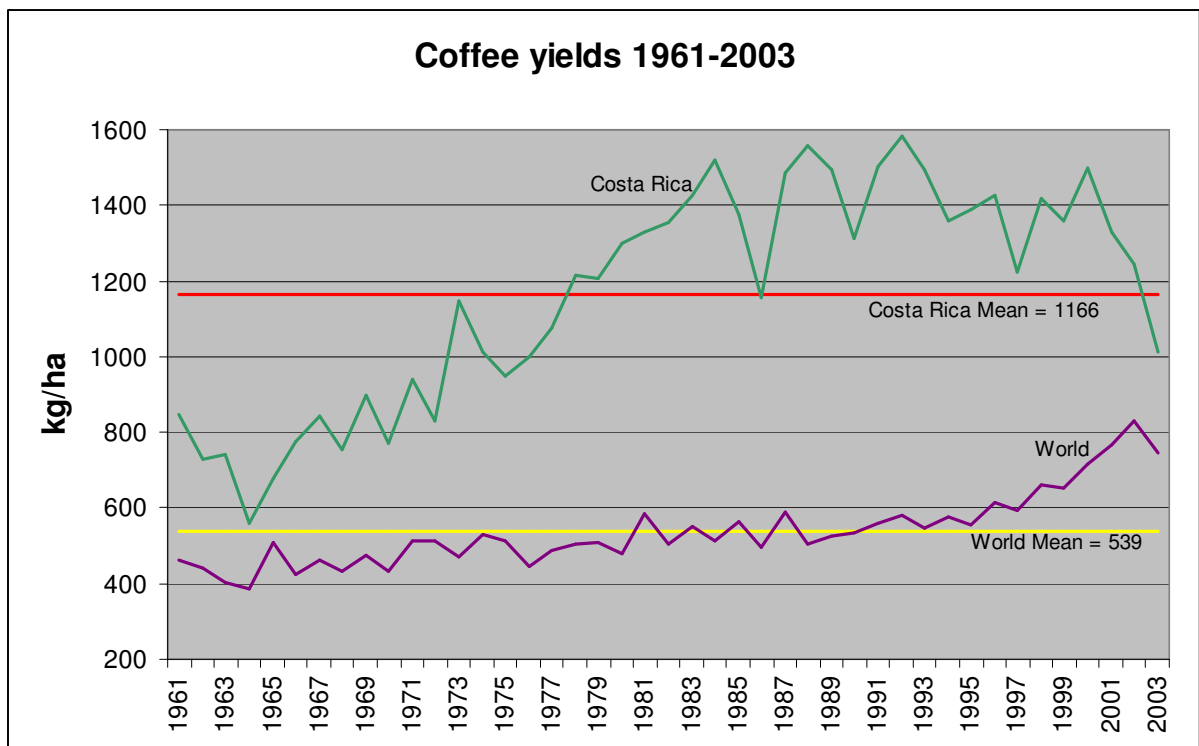


Figure 1.3.4. Coffee yields in kg/ha for Costa Rica and the world 1961-2003. Calculated from UNFAO (2005) and ICAFE (2003).

Chronic overproduction

*“Coffee gives you a jacket and it takes your shirt.” – Brazilian saying**

Coffee prices experience both short-term fluctuations and long-term cycles. The former are primarily influenced by speculative activity, with the latter being influenced by the relationship between world consumption and the amount of coffee available. The policies of the large trading houses also have a considerable impact on prices. Both supply and demand show low short-term price elasticity for coffee, meaning that prices have little short-term relationship to either the availability of coffee or consumers' interest in buying it (Portillo 1993).

As mentioned above, because there is a lag of several years between a producer's decision to increase supply and the time that supply reaches the market, supply and demand are rarely in equilibrium. This is exacerbated by the fact that small producers, confronted by low prices, will often *increase* supply in order to continue to earn a subsistence income (Pelupessy 1993 p. 41), while the traditional economic model expects them to reduce supply. Because the initial costs of planting and maintaining coffee trees make up such a large share of total production costs, farmers will usually continue to harvest and sell beans while prices are well below total average costs, in order to recover at least some of their initial investment (Lindsey 2003 pp. 3-4), further reducing the ability of coffee supply to respond to low prices.

Surplus beans from one harvest are carried over to the next in warehouses controlled primarily by large roasting companies or government entities in producing countries. The export price of coffee has a direct negative relationship to the size of these stockpiles (Daviron 1994 pp. 70-71), which continue to keep prices low even after production has decreased (Lindsey 2003 p. 4). “Boom” coffee cycles tend to be shorter than “bust” cycles, with low prices lasting an average of five years, and high prices only two (Morales 2000). As Wim Pelupessy (1993 p. 14) remarks, “We are not confronted by a fully competitive market, with transparency and free and equitable access by its participants.”

* Quoted in Pendergrast (1999), p. 323

Brazil is the world's largest producer of unwashed Arabica and the third largest producer of Robusta (ICO 2005a; 2005e). With its large land area in production, susceptibility to natural climatic fluctuations such as drought and flood (Pelupessy 1991), and reports of annual government subsidies of up to \$200 million to its producers (Anonymous 1995), Brazil's participation in the coffee market further magnifies the volatility of an already unstable product, making it by far the largest distorting factor in the global coffee market (Figure 1.3.5).

The first major coffee overproduction crisis of the modern era was in 1896-1908, brought on by the vast expansion of coffee area in Brazil – which, at the turn of the century, supplied about 75% of the world's coffee (Daviron 1994 p. 43) - and by a global recession (Jiménez 1994; cited in Kutschbach 1994a p. 14). The low coffee prices persisted even after the North American and European countries had recovered from the recession (Kutschbach 1994b p. 93). Beginning in 1907, Brazil began the first program of coffee “valorization,” an attempt to stabilize world prices by withholding stocks from the market (Brignoli 1994 p. 27). Prices recovered by 1910, stimulating another increase in the area under production (Kutschbach 1994b p. 96).

As long as Brazil remained an important enough producer to be able to hold up prices on its own, other producing countries were unwilling to enter into multilateral agreements to control supply, and instead took advantage of the situation to increase their own market share. Ironically, by propping up the world's coffee prices, Brazil encouraged the development of coffee production in other countries, and by the 1920's Africa, and other countries of Latin America, had begun to emerge as important producers of the bean (Daviron 1994 p. 43, 49). From the 1930s to the 1970s, France financed the expansion of coffee production in its colonies and favored imports from those countries, with the result that coffee production in French colonies in Africa increased by a factor of fifteen (Daviron 1994 p. 51).

The second crisis of the 20th century began in 1927, as coffee from newly planted regions around the world entered the market. It was soon compounded by the beginning of the Depression in 1929, which affected all exports, imports and the international monetary system (Kutschbach 1994b p. 107). Tropical countries watched the prices of

all their commodities fall, and Central America was particularly hard hit by the simultaneous slide in coffee and banana prices (Kutschbach 1994b pp. 115-117). That year Brazil began destroying coffee stocks outright, burning 4.68 million Mt of green coffee between 1931 and 1942, the equivalent of three years of world consumption (Cordero et al. 1987; cited in Portillo 1993).

The ability of farmers to survive the 1930's crisis had a great deal to do with diversification, particularly at the level of individual farms. Small-scale producers were less affected by this crisis than larger ones because of this diversification (Kutschbach 1994b pp. 119, 122). Costa Rica was somewhat insulated from the crisis by their relatively privileged position in the European market – in 1936, Costa Rican coffee was fetching the second highest price in the world. German policy changes in 1934, however, pushed Costa Rica into a more competitive market (Winson 1989 pp. 37-39).

In 1940, the United States and the Latin American producers signed the Interamerican Agreement, which initiated the world's first quota system (DiFulvio 1947; cited in Daviron 1994 p. 50). In the six months after signing the agreement, coffee prices jumped by 60%. After the U.S. declared war on Japan in 1941, the U.S. froze the prices of coffee imports until October 1946 (Daviron 1994 pp. 50-51). During the second World War, with Europe basically cut off from world markets, the United States was importing 80% of the world's coffee (Portillo 1993).

After 1946, coffee traded in an essentially free market (Portillo 1993). The postwar economic revival in Europe, combined with a drought and subsequent frost in Brazil, led to a dramatic upsurge in prices (Kutschbach 1994a p. 18). World stocks were reduced from 1 to 0.39 million Mt, and the price of Colombian milds went from \$0.19 to \$0.78 per pound (Portillo 1993). Between 1954 and 1956, new plantations in Brazil, Africa, Central America and Mexico came into production, resulting in another glut of coffee, accumulation of stocks, and an accompanying fall in prices (Rowe 1963; cited in Portillo 1993; Daviron 1994 p. 53).

In 1957 the Latin American producing countries signed the Mexico Accord, renewed a year later as the Latin America Accord. The goal of both agreements was to limit exports, but the strength of the agreements was limited without the support of the

African producers, who entered into the negotiations in 1959. An international accord was reached among producing countries in 1959, and renewed in 1961 and 1962 (Eisemann 1982; cited in Daviron 1994 p. 53).

Figures

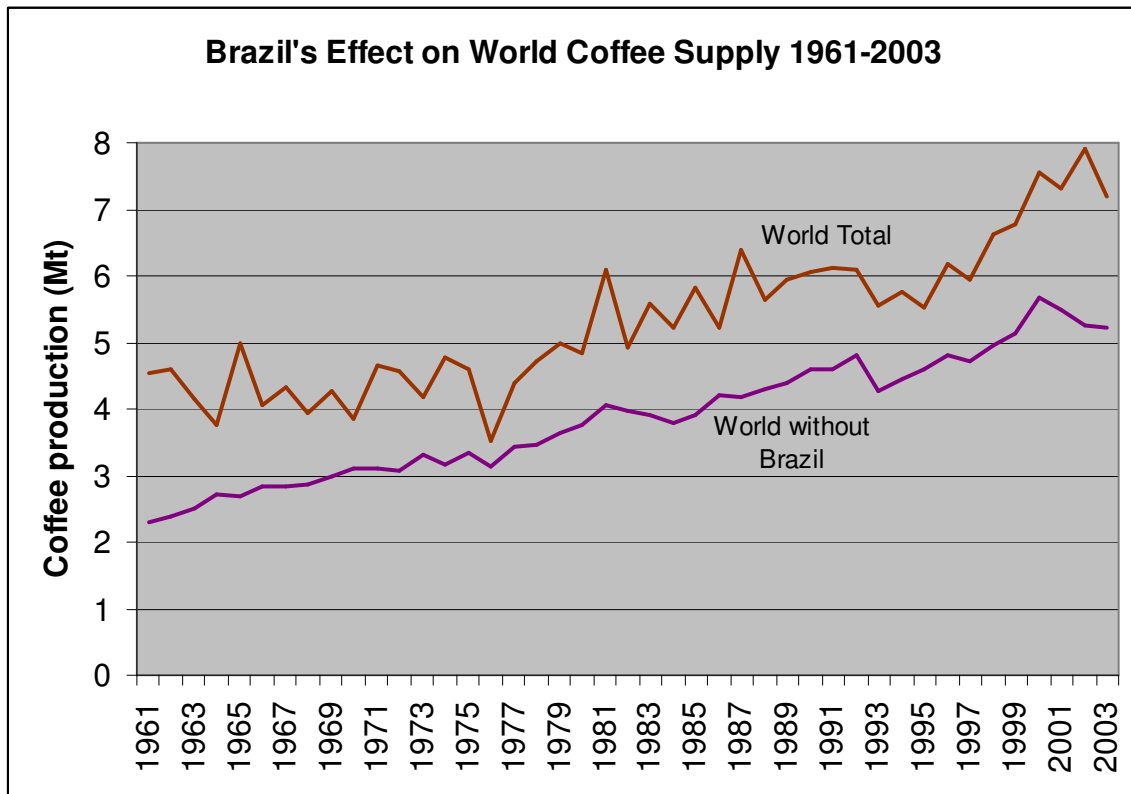


Figure 1.3.5. Brazil's effect on world coffee supplies. Data from (UNFAO 2005).

The International Coffee Agreement

*“It is plain that no program of economic development can be effected unless something is done to stabilize commodity prices.” -U.S. President John F. Kennedy, introducing the Alliance for Progress on March 13, 1961**

The Cuban revolution in 1959 intensified fears that an economic crisis in developing countries could pave the way for the spread of Communism, and the United States, through the vehicle of the newly-created Alliance for Progress, began seeking ways to stabilize coffee prices (Pendergrast 1999 p. 276). In an effort to curb the volatility of the market and provide some security for both producing and consuming nations, the first International Coffee Agreement (ICA) was signed in 1962 (Kutschbach 1994a pp. 18-19), with producers of 99%, and consumers of 85%, of the world's coffee as signatories (Daviron 1994 p. 57). The non-signatory nations were the countries of Eastern Europe and the Middle East, Argentina, Algeria, Chile, Magreb, New Zealand, South Africa, both Koreas and Hong Kong (Portillo 1993). The second ICA was signed in 1968, the third in 1976, and the fourth in 1983 (Pelupessy 1993 p. 33).

The ICA had four main tools available to it to control the price of coffee: pricing, taxation, quotas, and storage. Each ICA producing country had an annual fixed and variable quota. The fixed quotas accounted for 70% of supply, were based on historical production levels, and often were politically influenced. Variable quotas were based on a country's available stocks in proportion to total world stocks, and accounted for 30% of supply (Aguilar 1992 pp. 16-17).

Quotas would come into effect when an indicator price, calculated by averaging the price of Robusta and Arabica Other Milds, fell below a pre-specified price floor and remained there for at least 20 days. If the indicator price rose above a pre-set ceiling, quotas would be increased or dropped altogether. In the late eighties, this price band corresponded to around \$1.20 to \$1.40 per pound (Pelupessy 1993 p. 33). Quotas only applied to exports to other member nations, and did not apply to small-scale exporters (Aguilar 1992 p. 17). Countries that produced less than 6,000 metric tons of coffee were

* Quoted in Pendergrast (1999), p. 276.

exempt from the quota system, as their share of the total global quota was only around six percent (Pelupessy 1993 p. 33).

With the exception of a price spike in the late 1970's, prices were relatively stable at around \$2 a pound (in 2003 dollars) for the duration of the ICA (see Figure 1.3.6). Economic models indicate that the prices maintained by the ICA may have been as much as double the free-market price (Daviron 1994 p. 71).

There were a number of weaknesses in the ICA system. Because the quotas were historically and politically based (Pelupessy 1993 p. 38), they did not allow flexibility in dealing with increases in production or meeting the changing demands of coffee consumers. Producers of Other Milds, in particular, wanted an expanded market share (Aguilar 1992 p. 18), and the United States wanted increased access to higher quality coffee. During the 1980's, the price difference between Robusta and the Arabicas grew from 12 cents to 50 cents per pound of green coffee. Since the ICA indicator price was based on an average of the price for Arabica and Robusta, this meant that quotas could not be lifted for Arabica even when prices for that type of bean increased, and could not be implemented for Robusta when the price of that bean fell (Daviron 1994 p. 62; Portillo 1993).

Many countries considered the quotas to be inequitable, as they often left smaller producers holding back as much as half of their production, while countries such as Brazil and Colombia were able to maintain stocks at low levels (Daviron & Lerin 1986; cited in Daviron 1994 p. 16). In the 1970's, Brazil had 30-40% of the world quota but maintained 80-90% of the world stocks, but by 1989 their share of world stocks was only eight percent (Portillo 1993).

There was also contention over sales of coffee to non-member countries. When producing member countries had stocks available over their quota allocations, these could be sold to non-member countries for 40-50% below ICA prices (Daviron 1994 p. 59). The ICA permitted this, ostensibly, to encourage the growth of coffee consumption in non-traditional markets (Portillo 1993). Much of this coffee was then re-exported to member countries, earning it the nickname "tourist coffee" (Pelupessy 1993 p. 29).

While the non-member market served as an escape valve for producing countries to sell off excess stocks, it also undermined the system as a whole.

While in 1971-73 exports to non-member countries accounted for only six percent of world exports, from 1982 to 1989 they represented 15% (Daviron 1994 p. 59; Portillo 1993) and by 1990 they had expanded to 17% (Pelupessy 1993 p. 28). Indonesia was the biggest exporter to the non-member market, accounting for 20% of the total amount of coffee exported to non-member countries, but India, Mexico, Costa Rica and others were also very involved in this market (Portillo 1993).

A final difficulty with the ICA was the inability of producing countries to control overproduction. In fact, the ICA's reliance on past production for setting quotas created strong incentives for countries to ramp up production in order to secure a larger quota in subsequent years (Rice 1999). The years 1965-1966 began the greatest coffee production in history, stimulating the accumulation of large stocks (Portillo 1993). Figure 1.3.7 shows the difference between world production and consumption for 1961-2002. Up to 40% of green coffee loses its export quality in storage (Pelupessy 1993 p. 40). The cost of maintaining – or destroying - these stocks must be deducted from the artificially high prices promoted by the ICA in determining the true costs and benefits of the ICA, and may have been the ultimate cause of the ICA's collapse (Pelupessy 1993 p. 34).

Ironically, the artificially high prices maintained by the ICA stimulated expansion of growing areas, lack of diversification, and the use of higher inputs (Kutschbach 1994a p. 18; 1994b p. 120), contributing in the end to the decline of the ICA. For example, between the years of 1970 and 1992, coffee area in Mexico more than doubled (Bray et al. 2002). The second ICA included a “diversification fund,” with the goal of encouraging production of alternative products in zones that were marginal for coffee (Daviron 1994 p. 57), but this was dissolved in 1976 (Portillo 1993). Throughout the 1970's and 1980's, programs promoted by governments and international development agencies such as USAID encouraged “modernization” programs that increased yields (Rice 1999), raising the costs of production and compounding the problem of overproduction.

In 1972, negotiations for the third ICA broke down because consuming countries refused to adjust the price bands to account for the devaluation of the dollar (Portillo

1993). The economic clauses of the ICA were suspended and the Agreement operated without quotas or a price band until 1980, although a third ICA was signed in 1976 (Daviron 1994 p. 58). After record-high prices in the late 1970's due to a series of natural disasters (Pendergrast 1999), prices slumped again at the end of the decade, triggering the enactment in 1980 of the 1976 Agreement (Daviron 1994 p. 58).

In 1983, a set of reforms were proposed for the ICA. The United States, now under the direction of the free-trading Reagan administration (Dicum & Luttinger 1999), suggested abandoning quotas in favor of management of stocks. The European Union suggested a global quota that included sales to non-member countries. The Central American countries wanted selective quotas based on coffee type. None of the suggested reforms were adopted. Two negotiating blocks formed: Central America, the United States, Canada and Australia favored a new, objective division of the quotas, which would favor Central America and Colombia. Brazil, Colombia, Africa, the European Union and the Phillipines wanted to maintain the old quotas but control sales to nonmembers (Portillo 1993).

Producing nations had hoped that the 1986 Uruguay round of negotiations for the General Agreement on Tariffs and Trade (GATT, now the World Trade Organization) would improve their position in the market, lowering some of the barriers to importation of value-added goods. In fact, the Uruguay round had only a minimal effect on the coffee industry, with the EU agreeing to lower tariffs on green coffee from five to four percent (Pelupessy 1993 p. 38). The tariffs on value-added products remained.

In 1985, a frost in Brazil led to another price spike, and quotas were suspended from February 1, 1986 to October 6, 1987 (Pelupessy 1993 p. 38; Daviron 1994 p. 58; Portillo 1993). Prices began to fall again in 1987, and quotas were re-established in February of that year (Pelupessy 1993 p. 39). The fourth ICA was set to expire in 1992. Negotiations for a new agreement stalled in 1989, when the two major negotiating blocks could not reach an agreement (Portillo 1993), and the agreement was suspended in July of that year.

U.S. President George H.W. Bush, while an ardent free-trader, indicated in a 1990 letter to Colombian President Virgilio Barco a willingness to negotiate a new ICA, with

the explicit goal of controlling drug trafficking. By September of 1992, all countries were finally able to agree on a global quota that included non-member countries and to deal with the issue of quota selectivity in relation to coffee types. The United States, however, insisted on a system that would more or less mimic the free market (Portillo 1993). The final ICA expired in 1992, with no new agreement in sight.

Figures

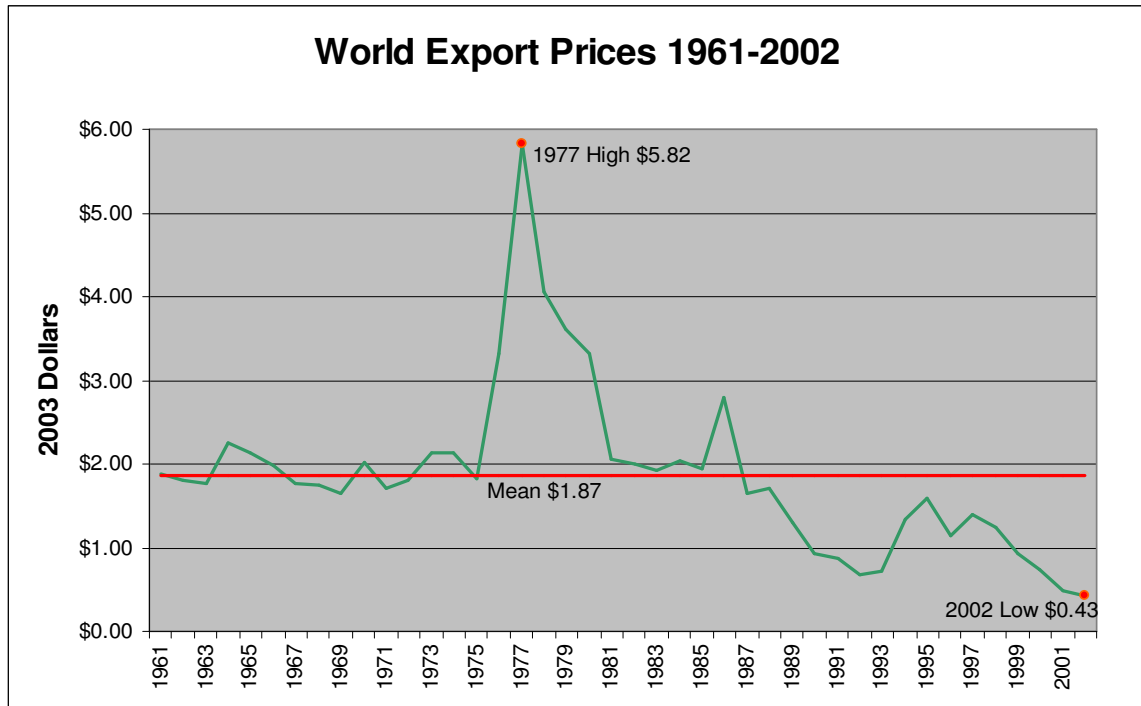


Figure 1.3.6. World export prices for coffee, all types, in constant 2003 dollars. Data from UNFAO (2005).

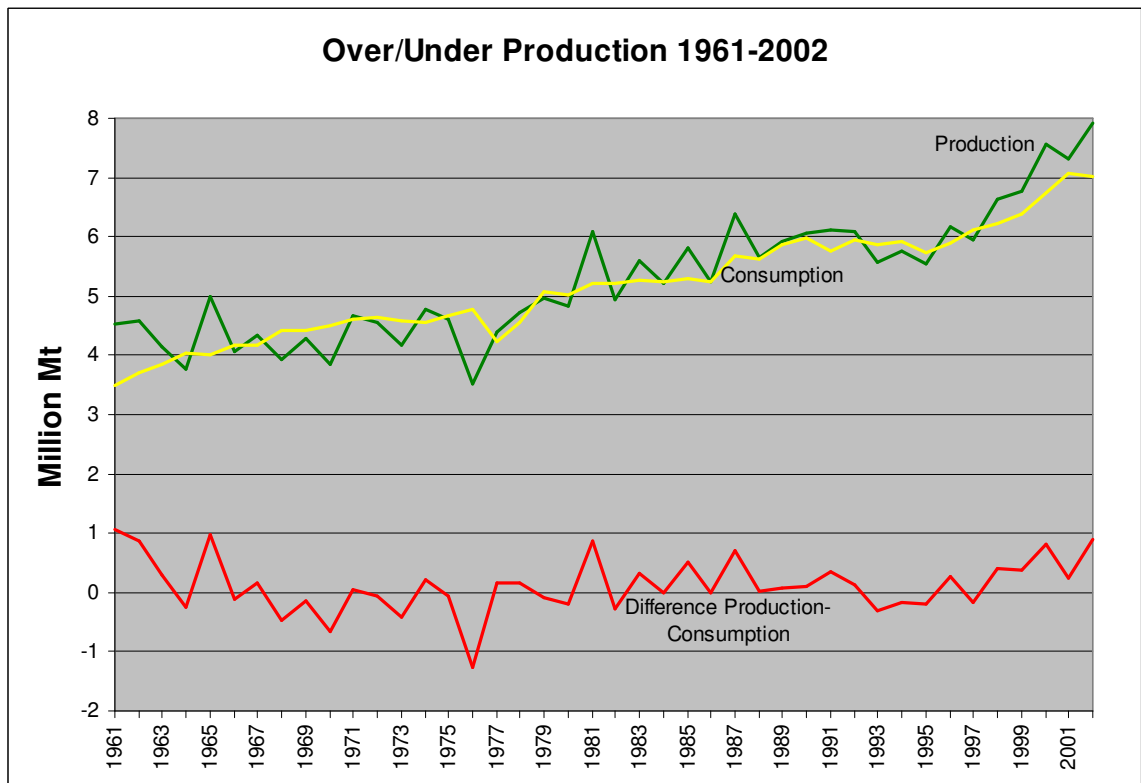


Figure 1.3.7. Total world consumption and production, and difference in world consumption and production, from 1961-2002. Calculated from UNFAO (2005) and (ICO 2005b).

New Players on the International Stage

Despite Brazil's market dominance, which continues to this day, other producing countries have gradually increased in importance. Between 1957 and 1972, Brazil and Colombia's share of the ICA quotas fell steadily, from a combined 54% to 46%, while countries in Africa and Asia increased their quota shares from 27% to 36% (Federación de Cafeteros de Colombia 1978; cited in Daviron 1994 p. 55). At its peak, in 1961, Latin America accounted for more than 76% of world production. By 2004, that share had fallen to 59% (UNFAO 1995).

In the early 1990's countries in Asia began to dramatically expand their coffee production. The UN Food and Agriculture Organization did not begin tracking aggregate data for Asian coffee production until 1992, but between 1992 and 2004, coffee production in Asia doubled from just under one million Mt to just over two, increasing from 16% to 27% of world supply. The area harvested went from 1.5 million to 2.2 million hectares, and yields increased from 678 kg/ha to 935 kg/ha (UNFAO 2005).

Asia's growth in this sector was driven largely by Vietnam and Indonesia. Between 1992 and 2004, Vietnam's production increased six-fold, from 119,000 to 835,000 Mt of green coffee. Indonesia's production increased 60%, from 437,000 to 702,000 Mt. In that same period, Brazil's production nearly doubled, from 1.3 to 2.5 million Mt. While in 1989, Vietnam was 20th in its share of world coffee exports, by 2002 it was second, after Brazil (UNFAO 2005). In 1993, Vietnam accounted for only 1.5% of world supplies. By 2002 its share was forecast to reach 8.0% (Franklin Lee* in U.S. House of Representatives 2002 p. 41) Figure 1.3.8 shows the growth in production in Brazil, Vietnam and Indonesia from 1992 to 2004.

Many authors have argued that the World Bank was involved in the expansion of coffee production in Vietnam. Oxfam International (Gresser & Tickell 2002) criticizes World Bank and IMF policies that encouraged over-dependency of developing nations on export commodities, and link these policies to the overproduction of coffee. In his book Coffee: A Dark History, historian Antony Wild (2004) states:

Both [the World Bank and the Asian Development Bank] had lent heavily to Vietnam in the mid 1990s in line with their mandate to stimulate low-cost production and end market inefficiencies. Having massively defoliated the nation with Agent Orange during the Vietnam War, the USA promoted – through the World Bank, in which it has a controlling stake – the refoilation of Vietnam with low-grade Robusta coffee bushes . . .” (p. 6)

The World Bank, however, has denied involvement in the expansion of Vietnam’s coffee industry (O'Brien & Kinnaird 2004). According to Miriam Wasserman (2002 p. 6), the World Bank “. . .says it resumed lending to Vietnam in 1994, after the country’s coffee expansion was already under way and that, though \$16 million from a loan to the Agricultural Bank was used to finance coffee farm rehabilitation, it has not lent directly to the coffee sector.” Robert Rice (1999) argues that coffee was one of a number of “black-listed” commodities for which the World Bank historically would not provide funding, citing interviews with World Bank officials in 1993.

The confusion, controversy and uncertainty over this issue may be a result of what Wild (2004) refers to as the “official veil of secrecy,” with the World Bank “unwilling to shoulder the responsibility of having contributed substantially to the collapse in world coffee prices” (p. 295). Nevertheless, without more complete information, it is difficult to support conclusions regarding the World Bank’s share of the responsibility for the coffee crisis.

In 2000, what appears to be the first mention in the Costa Rican press was made referring to Vietnam and Indonesia, rather than Brazil, as the primary sources of overproduction (Rojas 2000). Concerns over Vietnam’s growing role in the market increased as France announced plans to assist the Robusta-producing nation to begin growing Arabica (Ulett 2001).

As coffee production expanded in Asia, and as Brazil continued to ramp up production, large coffee roasters began utilizing new processing techniques, such as steaming, that removed the bitter taste from lower-quality coffee beans, enabling them to decrease the quantity of higher-quality Arabicas in their blends (Lindsey 2003 p. 5; Inter-American Development Bank et al. 2002). Thus, while both Indonesia and Vietnam produced predominantly Robusta (ICO 2005b), these new technologies meant that

Robusta was increasingly able to compete directly with Arabica in certain low-cost sectors of the market.

Despite the dramatic increase in Vietnam's production compared to earlier years, and despite the large amount of attention given to that increase, Brazil still remains the driving force in the world coffee market, accounting for most of the year-to-year variation (see Figure 1.3.5). In 2004, Brazil exported more than three times as much coffee as Vietnam, and nearly twice as much as Vietnam and Indonesia put together (ICO 2005e). Vietnam dominated the Robusta market, however, exporting more than four times as much Robusta as Brazil and twice as much as Indonesia (ICO 2005a; 2005e). Together, Brazil and Colombia exported nearly two-thirds of the world's Arabica beans (ICO 2005a; 2005e; 2005c).

Figures

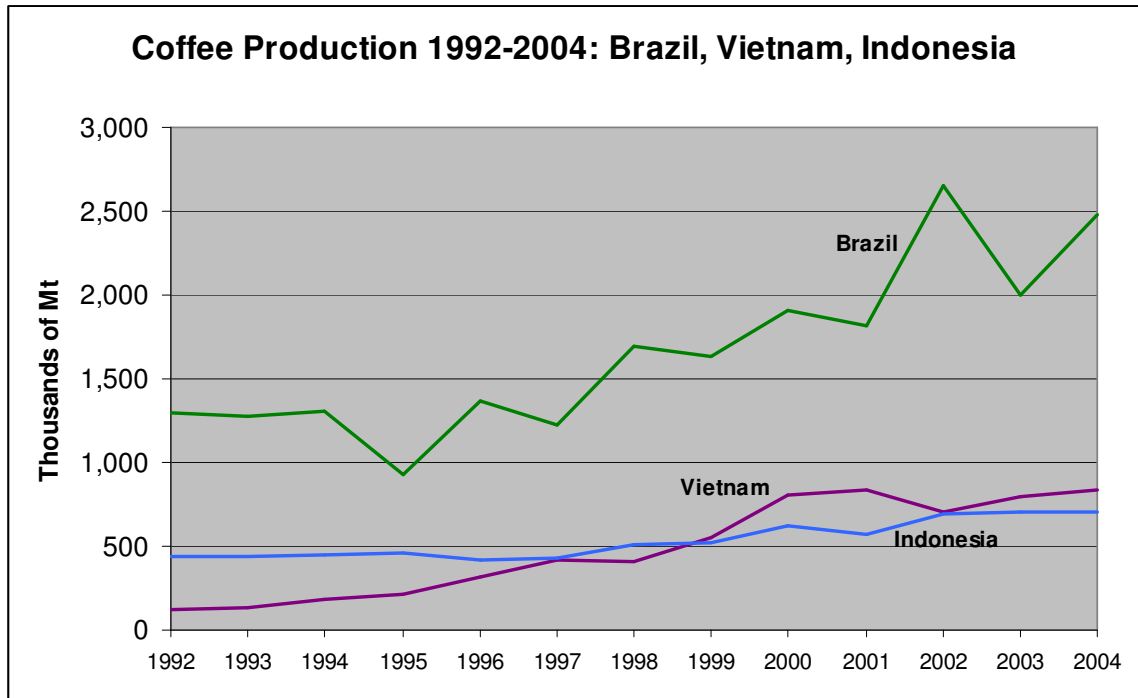


Figure 1.3.8. Increases in production in Brazil, Vietnam and Indonesia from 1992-2004. Data from (UNFAO 2005).

The Current Crisis

The 1980's have been called by some authors "the lost decade" in Latin America, characterized by economic stagnation, crippling foreign debt and new policies of "liberalization" that privatized many state functions (Kutschbach 1994b p. 124). The entrenchment of these policies make prospects dim for any future agreement resembling the ICA (Daviron 1994 p. 64), and the effects of the current crisis are so profound that they would be felt even long after such an agreement was implemented (Hilje et al. 1994 p. 163).

After the collapse of the fourth and final ICA in 1989, export prices fell by 40% in just a few months (Pelupessy 1993 p. 34), to the lowest level since the 1820's (Dumas 1992; cited in Kutschbach 1994a p. 22). For most Latin American countries, which had not begun producing coffee until the mid- to late-19th century, these were the lowest prices in history. From 1989 to 1991, exports exceeded world consumption, stocks built up in consuming countries to double the usual level, and production continued to rise. By September of 1991, prices on the New York Coffee, Sugar and Cocoa exchange were at \$0.50/lb, in real terms as low as during the Depression. Even as export prices of green coffee fell more than 40%, the price of roasted beans fell only 9.5% in the U.S. (Portillo 1993).

From 1990 to 1992, farmers worldwide earned \$8 billion less than the previous period, while exporting 1.6 million Mt more (Gutiérrez 1992; cited in Portillo 1993). Brazil alone lost an estimated \$1.5 billion a year in coffee revenues, and Africa lost \$3.2 billion. For comparison, World Bank aid disbursements to Africa amounted to \$2.9 billion during the same period – or less than the total amount of coffee revenues lost. The price of cacao, another product important to many coffee-growing countries, also fell in the early 1990's, reaching a 14-year low (Portillo 1993).

The situation was exacerbated by a concomitant collapse in banana prices. In the early 1990's, banana was the number one export from Costa Rica, accounting for 20% of export income. Coffee came in third, with 10% of export income. In Guatemala, coffee was first and bananas third, and in Honduras the two together accounted for 50% of export earnings. Panama, which depended on coffee for only 3% of export earnings,

received 45% from bananas, while in El Salvador, 45% of export earnings came from coffee.

Between June 1991 and June 1992, banana prices had fallen by 60-65%. The European Union announced a plan to implement a quota system favoring the countries of Africa, the Caribbean and the Pacific, and a tariff of 20% on banana imports from Latin America. The Union of Banana Exporting Countries, which consisted of Colombia, Costa Rica, Guatemala, Honduras and Nicaragua, predicted that these moves would decrease Latin American exports by as much as 30%, with up to 400,000 families losing their livelihoods (Murillo 1992).

By February of 1992, losses in coffee earnings to producing nations worldwide were \$6-7 billion, with Costa Rica losing \$100-150 million annually (Murillo 1992). The government of El Salvador had declared a state of emergency, and FEDECOOP requested that the Costa Rican government do the same (Vega M. 1992).

In Costa Rica, coffee had ceased to be profitable for most farmers. The average Costa Rican farm yielded 3,295 pounds of coffee per hectare at a cost of \$2,016 (in 1992 dollars) or \$0.61 per pound (Viquez 1992a). For the 1991-92 harvest, the average price paid to farmers was \$0.51 per pound, or \$1680 per hectare, for a net loss of \$0.10 per pound or \$336 per hectare (calculated from ICAFE data). One exporter prophesied that Costa Rica's coffee industry was "dying," and Mario Fernández, director of FEDECOOP, predicted the disappearance of small producers (Vega M. 1992). An op-ed in the daily newspaper *La Nación* remarked, "The global crisis affects Costa Rican society so deeply, it is as though it were a crisis in our own democracy" (Corrales B. 1992). This author insisted that Costa Rican democracy would be threatened unless a way could be found to help small farmers keep their land.

In 1993, a number of coffee producing countries agreed to implement a coordinated withholding of supply (Kutschbach 1994a pp. 23-24), which resulted in a small and temporary price recovery (see Figure 1.3.6). The average price of \$0.77 per pound paid to growers during the first half of 1994 (ICO 2005b) was finally enough to cover production prices, but not enough to provide significant relief to farmers, and early in the year, the Central American countries considered another coordinated withholding if

the price did not rise above \$0.79/lb (Murillo 1994), the price considered by the Association of Coffee Producing Countries to be the break-even point for farmers (Anonymous 1995). At the same time, the EU had still failed to reach an agreement with the Central American countries over bananas, further prolonging the uncertainty in that market (Associated Press Guatemala 1994).

Between 1989 and 1994, the export price of Costa Rican coffee never rose above \$0.84 a pound, making it the worst crisis in Costa Rican history (Muñoz N. 1997). Thanks to a frost in Brazil (Anonymous 1995), average green coffee export prices reached another peak in 1995 at \$1.31 a pound globally, then tumbled again, never to recover (data from UNFAO 2005). In Costa Rica, the price of coffee exports continued to rise for another three years, averaging \$1.45 a pound in 1998 (Fernández et al. 2000 p. 26). Only \$1.09, however, reached the farmer (Fernández et al. 2000 p. 27), at a time when the cost to produce a pound of coffee averaged \$0.92 (Barquero S. 1998).

In late 1998, the Brazilian plantations that had been re-planted after the 1994 frost began to come into production, and Brazil announced a large harvest (Morales Ch. 1999), prompting prices to fall again (see Figure 1.3.6). While the value of Costa Rica's coffee exports for the first half of 1998 were \$282 million, they fell to \$193 million for the same period in 1999 (Morales Ch. 1999). By mid-August of 1999, the price of coffee on the New York exchange had fallen to \$0.87, presumably on news that Brazil's 2000-01 harvest would reach 2.4 million Mt, instead of the usual 1.8 million (Barquero S. 1999). In the same year, the value of Costa Rica's banana exports had fallen by half from two years previous (Murillo 1999).

In 2000, consuming countries were maintaining stocks of green coffee equal to 5.29 million Mt, while global consumption was only 4.97 million Mt. Between January and December of that year, the price of green coffee on the New York exchange went from \$1.14 to \$0.67 a pound (Morales 2000). This was a more severe price drop than the post-ICA collapse of 1989 (Prendas 2001b). In October of 2000, Costa Rica and other producing nations again sought to raise prices by withholding 20% of their coffee harvest (Rojas 2000). Another plan was discussed at the time to permanently remove 10% of Central America and Mexico's lowest quality coffee from the market (Morales 2000).

Also in 2000, the effect of falling coffee prices on national economies was further compounded by high oil prices, which had risen nearly 60% over the two previous years. The Costa Rican newspaper *Al Dia* reported that in January 1998, the proceeds from one *quintal* (46 kg) of green coffee would purchase 8.39 barrels of crude oil, but by October 2000, 33 months later, one *quintal* of coffee would buy only 2.95 barrels of crude. Costa Rica received \$19 million less for its coffee exports in 2000 than in 1999, while spending \$140 million more on oil. Higher oil prices increased production costs and made improvements to infrastructure more costly (Rojas 2000).

Meanwhile, the EU had still not reached an agreement with producing countries over bananas, and the devaluation of the Euro was further impacting banana prices, though the decline was not nearly as drastic as for coffee. In 1999 Costa Rica had exported 115 million 18 kg boxes of bananas at \$5.45 a box; in 2000 they exported 100 million boxes at \$5.20 a box (Morales 2000).

By 2001, it was clear that the 20% retention scheme had failed to affect prices, with only Costa Rica, Brazil and Colombia complying with its terms. Even the substantial quantities held by the latter two countries had little effect, in part because Brazil had undertaken a program to devalue its currency to increase exports, further depressing prices (Prendas 2001a). Oxfam International reported that in Vietnam's Dak Lak province, coffee prices only covered 60% of production costs (Gresser & Tickell 2002 p. 2).

Plans were made to destroy the lowest-quality five percent of Costa Rica's coffee, but this was not expected to have any effect on prices for up to 18 months (Prendas 2001b). That year, Costa Rican coffee specialist Rodrigo Jiménez Robles estimated farmers' costs of production at \$0.82 per pound (Mora 2001a), while the average price paid to growers that year was \$0.48 per pound (Fernández et al. 2002). Eugenio Porras Vargas, president of the Costa Rican College of Agronomic Engineers, predicted that in the 2001-02 harvest farmers would lose nearly \$1,000 per hectare (Mora 2001a).

In early 2002, new hopes for a price recovery were rekindled when Brazil predicted a small harvest for 2002-03, began paying its farmers to withhold a part of the harvest, and began to revalue its currency (Prendas 2002). That recovery appears to be

finally materializing, although it has taken longer than was hoped. While Brazil's production was down nearly 20% in 2003, by 2004 it had rebounded nearly to the record levels of 2002, and Vietnam and Indonesia have continued to maintain their high production levels (UNFAO 1995). Nevertheless, prices have improved. In 2004, the last year for which full data were available, the ICO indicator price averaged \$0.62 a pound, while prices in 2005 averaged \$0.90 a pound through October.

It appears that the increase in prices has largely been driven by higher prices for Arabica beans. Prices for Other Milds averaged \$1.16 a pound for January-October 2005, while averaging \$0.51 for Robustas. From January 2003 to October 2005, the price differential between Robusta and Other Mild Arabicas grew from 37.2% to 54.8% (ICO 2005d), although a drought in Vietnam has begun pushing Robusta prices upwards again (Osorio 2005a). In September of 2005, Brazil announced the lowest level of government and private stocks ever recorded for that country. Catastrophic climatic events in the Gulf Coast region (where a quarter of U.S. green coffee stocks were stored), Mexico, and Central America are also likely to impact prices in the near future (Osorio 2005b). While the rebound in prices in 2005 certainly represents an improvement in the position of many coffee farmers, the ICO indicator price of \$0.90 still represents only half of the historical average (UNFAO 2005), and the coffee crisis is far from over (Osorio 2005c).

The remainder of this study will focus on the effects of the crisis through 2003, the year in which a local case study was conducted in southern Costa Rica. In that year, the ICO composite price averaged \$0.52 per pound, with Other Milds, the type of coffee produced in Costa Rica, averaging \$0.64 per pound (ICO 2005d).

II. Social, Economic and Environmental Effects of the Crisis

To understand the effects of a prolonged price slump such as the one we are witnessing today, it is important to understand the responses of farmers and the governments of producing countries to price swings. The long-term development of a nation dependent on the production of a raw material depends on investing profits during good years in the diversification of the economy (Brignoli 1994 p. 30). The typical response to a spike in prices such as that which occurred in the late 1970s (see Figure 1.3.6) is a syndrome known as “Dutch Disease” (Edwards 1984; Bevan et al. 1990; both cited in Pelupessy 1993 p. 26). Instead of using the windfall to improve infrastructure, diversify production or make other “rainy day” provisions, countries and individuals tend to respond by increasing consumption, especially of imports, which in turn drives increasing inflation, leaving producers even more dependent on coffee and more vulnerable to the inevitable downswings in the market.

In turn, when prices drop, the first response of most farmers is to cut costs, starting with labor intensive activities and investments in fertilizers and pesticides, up to and including complete abandonment of the plantation except for the harvest (Pelupessy 1993). In regions where most labor is performed by paid workers, this has immediate effects on employment levels and long-term effects on the productivity of the land. In El Salvador, for every one percent that costs are cut, approximately two percent of productivity will be lost (Pelupessy 1993 p. 26). This practice is most pronounced in countries where coffee dominates the economy, there are few alternative land uses, most coffee is produced by small farmers, or structural adjustment programs call for increases in the production of export products (Pelupessy 1991). In Central America, outright abandonment of the land by small producers in times of crisis is very common (Pelupessy 1993 p. 13).

Another, paradoxical effect in many countries is that, in times of low prices, small farmers will often attempt to *increase* production in order to meet their basic financial needs. Because of the combination of this factor with those in the above paragraph, coffee supply tends to be unresponsive to prices. For example, short-term (up to one

year) supply elasticity is only 0.03 in Central America, rising to between 0.14 and 0.77 at six years or more (Pelupessy 1991).

This chapter will examine the social and economic effects of the most recent coffee crisis across scales, ranging from a global perspective to the level of individual households, with a focus on the district of Agua Buena, in the *canton* of Coto Brus in Costa Rica.

1. International

Low coffee prices hit the entire economies of coffee-producing nations hard. Most coffee-producing nations are deeply in debt, and rely on exports for badly needed foreign exchange. Export taxes are often heavily relied upon to fund government operations. In the three years after the suspension of the International Coffee Agreement, from 1989 to 1992, the Central American countries lost an estimated \$3 billion in export earnings (Pelupessy 1993 p. 13). The current crisis has coincided with a wave of privatization of state functions in producing countries, making state intervention to assist struggling farmers far less reliable (Kutschbach 1994b p. 120).

Some countries' exchange positions have been hit harder than others. In Brazil, for example, while coffee accounted for 50% of foreign exchange earnings at the beginning of the 1970's, by the early 90's its share had shrunk to four percent, mainly due to industrialization (Portillo 1993). Thus, Brazil's economy was considerably more shielded from the crisis than other countries, for which coffee was more dominant in the export economy during the same period.

Consolidation of the industry has continued throughout the 1990's, giving large traders and roasters even greater control over pricing and supply. At the end of the 1980's, eight trading houses controlled over half of world supply (Pelupessy & Tilburg 1994 p. 247; EIU 1991 p. 94). In the five years following the suspension of the ICA, five major trading houses closed and three merged (Daviron 1994 pp. 66-67). By 2002, half of the world's coffee beans were controlled by five roasters: Kraft, Nestlé, Procter & Gamble, Sara Lee, and the German roaster Tchibo (Gresser & Tickell 2002 p. 2).

The percentage of the price of a pound of coffee that goes to farmers has shrunk throughout the 1990's. In the 1980s, coffee farmers received around 25% of the worldwide export price of coffee, with a net profit after expenses of approximately 15% of the end cost to the consumer (Pelupessy 1991). According to Gabriel Silva, General Manager of the National Federation of Coffee Growers of Colombia, in the early 1990's a total of about a third of the retail price remained in producing countries, but that share had fallen to less than 12% by 2002 (U.S. House of Representatives 2002 p. 62). That same year Néstor Osorio, Director of the International Coffee Organization, told the Costa Rican newspaper La República that the percentage had fallen to less than 9% worldwide (Anonymous 2002).

Pelupessy and Tilburg (1994 p. 247-248) cite the specific example of Holland to illustrate this phenomenon. Prior to 1989, Central American farmers received 25% of the retail price of coffee in Holland, with a net profit to the farmer equal to 15% of the retail price. By 1994, those figures had fallen to 14% and 10%, respectively. Additionally, when prices fall, producing countries tend to lower export taxes, thus further reducing the percentage of the retail price that remains in the producing country (Pelupessy 1991).

There are a number of factors influencing how farmers and their land will be affected by low prices. The most important of these can be loosely categorized as relating to the three types of inputs mentioned in Chapter 1.3: land, labor and technology. Other factors influencing the effects of a price crisis that do not fall neatly into these three categories include: the level of state intervention, the level of indebtedness of the producer, the amount of coffee stocks held by a country, and efficiency of production (Pelupessy 1991; Kutschbach 1994b p. 120).

Land

Coffee farmers who enjoy optimal environmental conditions are able to better survive market downturns: in sub-optimal areas, coffee is only profitable when it commands high prices (Kutschbach 1994c p. 225). Coffee grown at higher altitudes, while commanding a higher price, also offers lower profit margins. (Kutschbach 1994b p. 85). Farmers with more diversified production systems will face fewer risks but often

forego potentially higher incomes (Reeves & Lilieholm 1993; Kutschbach 1994b p. 81; Perfecto et al. 1996; Moguel & Toledo 1999; Gobbi 2000; Ramirez & Sosa 2000).

In Latin America, the crisis has had the effect of forcing farmers to diversify their production (Kutschbach 1994c p. 226). Colombia, Ecuador, El Salvador and Guatemala began diversification programs in the early 1990's and implemented incentives to reduce coffee production (Murillo 1992). In Minas Gerais, Brazil, farmers began changing their land use from coffee to eucalyptus, nuts, passionfruit, or cattle ranching. The number of coffee trees in Brazil fell from 4.2 billion to 3.2 billion from 1990 to 1992, and of those remaining, only 20% were being tended regularly (Portillo 1993). In more remote areas the production of illegal crops, such as cocaine, expanded (Wilson 2001; cited in Philpott & Dietsch 2003; Kutschbach 1994c p. 235). Some authors have expressed concern that the crops replacing coffee may be less appropriate to the steep slopes where coffee is frequently grown, resulting in increased soil erosion. Where shade coffee is grown, changing to other crops can result in the clearing of the shade overstory (Varangis et al. 2003 p. 18).

Farmers are also leaving the land altogether, either by choice or because of debt. In Guatemala, as many as 20% of farmers had lost their land by mid-1992, and many Mexican farmers began migrating to the United States (Murillo 1992). In Peru, where the cost of production was \$0.68 per pound and the price paid to farmers \$0.27, an estimated 25,000 hectares of coffee had been abandoned by 2001. Many of those farmers turned to coca, which paid three times as much as coffee. Governments in many Latin American countries have been intervening in a number of ways to support production (Prendas 2001a).

Productive coffee area dropped sharply after the Brazilian frost and other natural disasters of 1976, reaching a low of 7.9 million ha, then rebounded quickly (Figure 2.1.1). Productive coffee area peaked in 1990 at 11.4 million ha, then fell 12.3% by 1995, to a 15-year low of 10.0 million ha. After the price recovery of the late 90's, productive area increased slightly again, peaking at 10.6 million ha. As of 2004, it had dropped back to 10.1, just above the 1995 low (data from UNFAO 2005).

The total coffee-producing area for Asia, Africa, and Latin America and the Caribbean are shown in Figure 2.1.2. Productive area in Africa has been in steady decline since 1990, dropping by 42.6% by 2002, and area in Latin America declined 17.6% from 1989-1995, then stabilized. Meanwhile, productive area in Asia increased by 55.7% from 1992 (the earliest year for which the UNFAO offers data) to 2004.

Labor

Coffee farmers with only a few hectares of land generally rely entirely on family members for labor. Since family labor is unpaid, these farmers can tolerate lower prices and turn a profit even in marginal areas. In the case of larger farms that use paid laborers, lower coffee prices will tend to depress wages (Kutschbach 1994b pp. 89-90). Due to the seasonality of labor needs, even in good years the families of a large percentage of the day laborers on the world's coffee plantations lack basic nutritional requirements for five months out of every year (Pelupessy 1993 p. 17). Thus, the effects of a downturn in coffee prices are devastating for wage laborers in the coffee sector.

By 2001, according to the Costa Rican Chamber of Coffee Growers, farmers in El Salvador, Honduras and Mexico were not harvesting their coffee because it cost more to pay pickers than they would receive from their coffee. In Nicaragua, only 1,800 of 40,000 farmers could afford to finance their harvests (Prendas 2001a; 2002). By 2002, the Costa Rican daily *La República* reported that half a million workers in Central America and Mexico alone had lost jobs (Anonymous 2002). In 2003, the World Bank estimated that 190,000 permanent jobs and 350,000 seasonal jobs in coffee production in Guatemala, Honduras, El Salvador and Costa Rica had been lost (Varangis et al. 2003 p. 17).

Many people in coffee-growing areas have responded to the reduction in employment and the low coffee prices by migrating to urban areas and to more developed countries. In May of 2001, the bodies of fourteen migrants were found dead on the U.S.-Mexican border, six of whom were identified as coffee workers (U.S. Rep. William Delahunt, in U.S. House of Representatives 2002 p. 9).

Technology

Of course, as a compromise between the typically intensive regime of inputs prominent during years of high prices, and complete abandonment or neglect of coffee farms, during price slumps a farmer can to continue to maintain and harvest from their coffee trees while lowering expensive inputs. At a Congressional hearing on the coffee crisis in 2002, Franklin Lee* of the U.S. Department Of Agriculture testified that farmers worldwide were reducing fertilizer and pesticide inputs (U.S. House of Representatives 2002 p. 43).

Hard data on use of chemical inputs in coffee-growing regions worldwide are extremely limited, and do not allow for discussion on a global scale. Data from the UN Food and Agriculture Organization (2005), for example, show that fertilizer use in the countries that were the top 10 coffee producers in 1989 increased by 63% from 1989 to 2003, but it is impossible to know on which crops these fertilizers were used. Changes in technology use are, therefore, reserved for discussion on a local scale.

* Deputy Administrator for Commodity and Marketing Programs, Foreign Agricultural Service, USDA

Figures

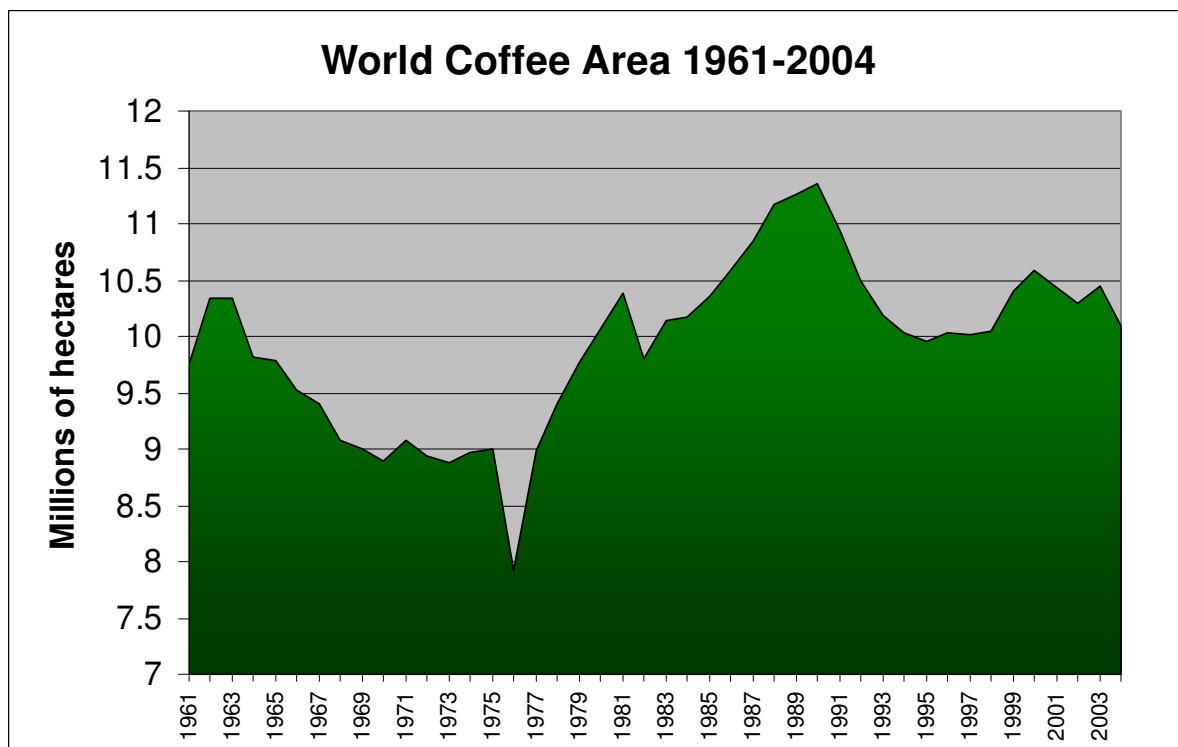


Figure 2.1.1. Area producing coffee worldwide from 1961-2004, in millions of hectares. Data from UNFAO (2005).

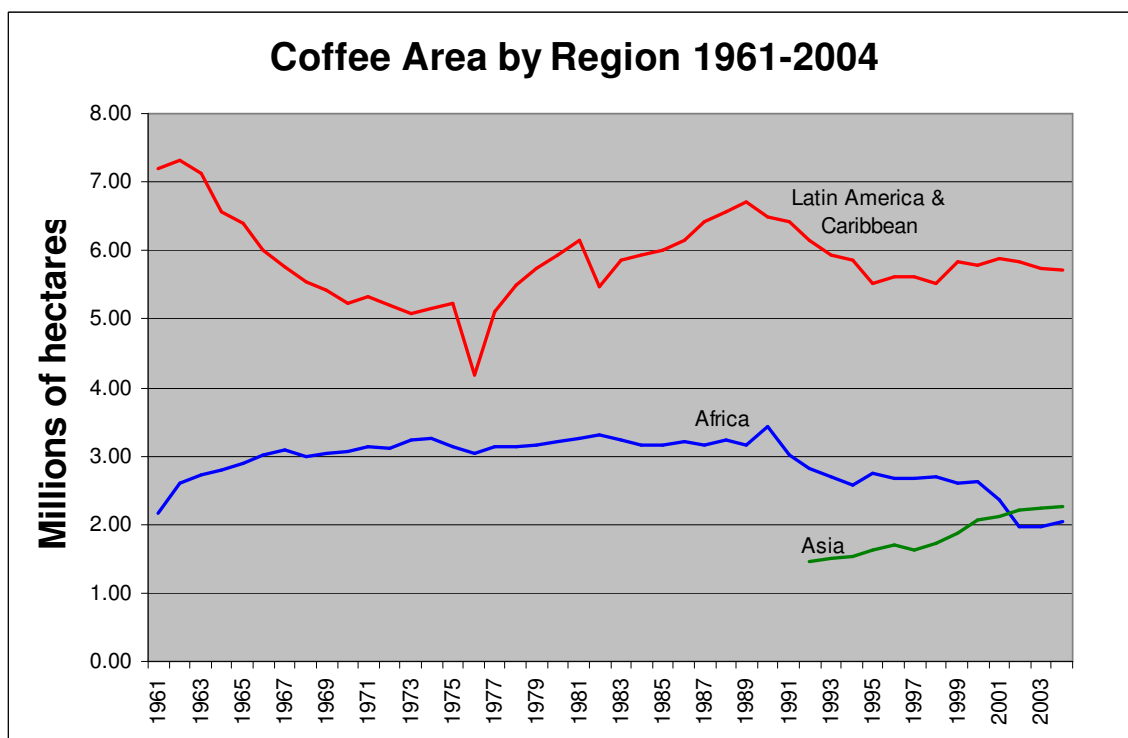


Figure 2.1.2. Area producing coffee by region, 1961-2004, in millions of hectares. Data from UNFAO (2005).

2. *Costa Rica*

In Costa Rica, the coffee/banana crisis of the late 1920's and the Great Depression did not result, as in other Latin American countries, in violent upheavals. Instead, structural and institutional solutions were sought to stabilize the economy and preserve order. The result of this period was an enlargement and strengthening of the role of the Costa Rican state, a role which continued throughout the 20th century (Kutschbach 1994b p. 117). This active participation by the state may have shielded Costa Rican producers from some of the worst blows of the current crisis, but farmers are still enduring great suffering and economic hardship.

Institutional Responses

In early 1992 the Costa Rican government reduced the export tax on coffee by one percentage point, and reduced from 1% to 0.5% the tax paid by producers for the support of ICAFE (Briceño 1992). That May, the government suspended exports for ten days and called upon neighboring countries to join, but the move had no effect on prices (Murillo 1992). A \$50 million National Coffee Stabilization Fund (FONECAFE) was created, and distributed to farmers as loans to be paid back when prices recovered (ICAFE 1993 p. 74).

By 1997, the Costa Rican farmers had paid back the \$50 million in loans, plus an additional \$10 million, which was to be held in reserve for future crises (Muñoz N. 1997). In 2001, FONECAFE paid out another \$75 million in loans to growers, leaving the fund depleted (Ulett 2001). The first \$25 million disbursement amounted to a subsidy of about 6 cents per pound, with over 7,000 farmers receiving less than \$10 each (Mora 2001a). Two additional \$25 million disbursements were made in 2001 (Ulett 2001). The loans were for a term of ten years, at eight percent interest, to be paid yearly beginning in 2003 (Prendas 2001b).

The Costa Rican government also began to push increased productivity as a way out of the crisis (Anonymous 1992a), because, when prices were lower, many farmers believed they could continue to meet their basic needs only by selling more coffee (Alfaro 1992). At 1993 prices, it was estimated that a farmer needed to yield 1800kg per

hectare to cover production costs, or about 300 kg more than the national average at the time. Programs were initiated to find ways to improve yields without raising input costs, such as through new pruning regimes (Vargas 1993).

Squeezed by declining prices and harvests, and by the lack of available credit, four of Costa Rica's *beneficios* were forced to close between 2001 and 2002. Other, smaller *beneficios* had also opened to process specialty coffees (Barquero S. 2002). FEDECOOP purchased a roaster in Miami, in an effort to circumvent tariffs imposed on roasted coffee (Ulate 1997). To secure higher prices, some *beneficios* were selling directly to U.S. roasters (Ulett 2001).

Farmer Responses

Even in the first few years of the current crisis, Costa Rican farmers who had lived through previous ones reported that this one was the worst they had experienced (Hilje et al. 1994 pp. 165-166). The savings and loan crisis of the late 1980s had wiped out the life savings of many, leaving them with few resources to withstand low prices (Hilje et al. 1994 p. 182). While devaluation of the colón could have lessened the impact of falling prices to some degree, the policies of the Central Bank prevented the full benefits of this from being passed on to the producer (see also Chapter 1.3) (Vega M. 1992).

Land

The crisis has, to some degree, encouraged diversification. The interplanting of citrus and plantain among the coffee bushes, which lost popularity as more farmers adopted the technified model, has re-emerged as low prices continue. In 1992, FEDECOOP proposed the creation of a credit program to help farmers below 900 meters to diversify (Viquez 1992a). Unfortunately, for many, "diversification" means a shift to cattle ranching (Dicum & Luttinger 1999, pers. obs. 2003).

Other strategies used by farmers are to abandon coffee and plant something else or, when the farmer is indebted or without other options, to sell the land and seek work as a laborer (Hilje et al. 1994 p. 184), especially in banana plantations (Anonymous 1992a). By mid-2001, the Costa Rican National Chamber of Coffee predicted that 60-70% of

coffee farmers would eventually abandon the crop altogether. Abandonment of the land provokes migration to the cities, expanding what are known as “rings of misery” (Mora 2001a).

Labor

During interviews of Costa Rican coffee farmers conducted in the early 1990’s regarding the coffee crisis, most farmers agreed that the largest coffee farm one individual person can care for year-round, not including additional labor needed during peak periods such as the harvest, is about 3.5 hectares, beyond which it becomes necessary to hire additional permanent labor. Labor in Costa Rica is expensive in comparison to other coffee-producing nations. This is most keenly felt by small and medium producers, who cannot guarantee year-round work for laborers (Hilje et al. 1994 pp. 168-171). As farmers cut costs, work has become more scarce in coffee regions, especially for pickers (Hilje et al. 1994 p. 185; Kutschbach 1994c p. 227). In some cases, farmers will not even harvest their own coffee, because they can’t afford to pay the pickers, or they earn more in wages from picking others’ coffee than from selling their own (Hilje et al. 1994 p. 196).

By 2001, unemployment had become a major problem in coffee-growing areas (Mora 2001a). Many farmers stopped pruning shade trees because of labor costs (Brenes 2002). Between the 1999-2000 and 2000-01 harvests, the number of permanent coffee workers fell 2.5-3.4% and the number of pickers by 18%. The total number of work days fell 12.3%, at an average value of \$7.57 per day. The total reduction in employment was equivalent to an annual \$84 per hectare (Valverde 2002). Between 1992 and 1996, the proportion of the Costa Rican workforce employed by coffee declined from 6.1% to 4.9% (ICAFE 1993 p. 91; 1997 p. 85).

Wages for pickers stagnated at 300 *colones* per *cajuela* from 2000 through 2003 (Prendas 2001b, pers. obs.), which actually represented a 22% drop in real terms (2003 dollars). It takes about 90 minutes for an experienced picker to fill a *cajuela* (Brenes 2002), making the hourly rate approximately \$0.50 an hour in 2003. These low wages, and a lack of permanent employment in the coffee industry, created a paradoxical labor shortage during the harvest even as year-round unemployment increased. Farmers were

forced to allow pickers to include green berries in the harvest in order to attract workers, which lowered the quality of their coffee (Prendas 2001b). In 2001, the ICAFE asked parents to send their children to work in the fields after school. As many as 5,000 Mt of coffee, or 3.3% of Costa Rica's harvest, were lost that year due to labor shortages (Quesada & Marín 2001; Fernández et al. 2002).

Technology

The level of technology used in Costa Rica is quite high relative to other coffee producing countries (Kutschbach 1994c p. 231). This has given Costa Rica the highest coffee yields in the world, but has also dramatically increased production costs, and thus made the current crisis more difficult to endure (Hilje et al. 1994 p. 167). In the late 1990's, approximately 30.6g of the herbicide Paraquat, 58.0g of the fertilizer ammonium nitrate, and 6.0g of the fungicide copper hydroxide were released into the environment for every pound of Costa Rican coffee produced (Pelupessy 1997 p. 38). Using an average yield of 3,000 pounds per hectare, this is the equivalent of 92kg of Paraquat, 174kg of nitrate, and 18kg of copper per hectare.

In light of this heavy use of inputs, therefore, the most immediate response of farmers has been the reduction in agrochemical use (Hilje et al. 1994 p. 183). Between 1990 and 1995, the number of coffee producers in Costa Rica who applied fertilizer to their farms fell from 93.5% to 85.8% (ICAFE 1997). Despite this apparently small reduction, however, it is clear that many farmers who continued applying some fertilizers reduced the overall amount of nutrients applied. Between the 1988 and 1992 harvests, the average amount of nitrogen, phosphorus, potassium, magnesium and boron applied per hectare of coffee fell by almost half (ICAFE 1993 p. 66). As one farmer reported, "if we fertilize we don't eat, and if we eat we don't fertilize" (Hilje et al. 1994 p. 184).

Overall, the consequences of the decline in fertilizer use on coffee yields were dramatic: some claimed that, in some areas, yields declined by nearly 90% (Viquez 1992a). Many also contend that reduction in chemical inputs tends to reduce the quality of coffee. Eduardo Kooper of the Costa Rican Association of Fine Coffees reported in 1997 that the quality of Costa Rican coffee had gradually declined over the previous 10 years (Ulate 1997). In 1998, ICAFE began to implement a program encouraging farmers

not to neglect their fields (Barquero S. 1998). Reductions in inputs continued, however: between the 1999-2000 and 2000-01 harvests, total inputs declined 21.9%, or \$101 per hectare (Valverde 2002).

The reduction of chemical inputs in coffee does not seem to have had any important effect on Costa Rica's total chemical use. In 2001, a study by the Costa Rican Ministry of Agriculture (MAG) revealed that imports of agrochemicals and their active components had remained level for four years (1997-2000) (Mora 2001b). During the same period, the area of Costa Rica devoted to crops increased by 17,951 ha, or 4.1% of the area in 1996 (SEPSA 2002 p. 18). Thus, the total amount of chemicals used per hectare fell by approximately 5% during those four years.

The combination of lower chemical and labor inputs, and a reduction in the land area devoted to the crop, have resulted in a nationwide decline in total coffee production. This decline has been most dramatic since the turn of the century. The 1999-2000 harvest cycle saw the third largest harvest in Costa Rican history, at 162,600 Mt. By the 2003-04 harvest, production had dropped to 110,136 Mt, the lowest since 1986 (calculated from ICAFE 1993; 2005b; Fernández et al. 2000).

3. *Coto Brus*

Coto Brus is the easternmost canton of the southern Costa Rican province of Puntarenas, with a land area of 935 km², divided into four districts (Rojas 1988). It is one of the most recently-settled cantons in Costa Rica (see Manger (1992) for a detailed description of the geography and historical background of Coto Brus). Until the early 1990's, Coto Brus was one of the four fastest-growing cantons in the country (Viquez 1992b), and its population more than doubled between the 1974 and 2000 censuses (DGEC 1974; INEC 2001). In the 2000 census, Coto Brus had a population of 40,082. The population was nine percent urban, with a literacy rate of 91.4%, a mean educational level of 5.5 years, and 22.9% of residents with a secondary education or higher, all lower than the nation as a whole (INEC 2001).

Although there has recently been a relative increase in tourism and industry in Coto Brus (M. Rosemeyer, pers. comm.), the boom experienced by the rest of the country

over the last decade has, for the most part, not reached this remote area, which still remains relatively isolated and undeveloped. There is a sense among many of the population of neglect and abandonment by the politicians in the capital, giving Coto Brus the nickname “the forgotten canton” (Arguedas M. 1988, Leonel Sanchez,* pers. comm. 2003). Farms in the region are less diversified and mechanized than the rest of the country. The canton receives fewer services, so farmers must do for themselves things, such as road maintenance, that would normally be provided by the government (L. Sanchez,* pers. comm. 2003). In 2003 the Brunca region of Costa Rica, which includes Coto Brus, had the highest number of poor households in the country, with 33.6% of homes in poverty, 21.5% unable to satisfy basic needs, and 12.1% in extreme poverty (INEC 2003b).

The first coffee harvest took place in Coto Brus in 1949, and the first *beneficio* was constructed there in 1952 (Manger 1992 p. 70). As of 2001, Coto Brus had 11,633 hectares of coffee and eight *beneficios* (Fernández et al. 2002 p. 17, 56), three of which were cooperatives, the latter of which processed 60% of the *canton's* coffee (Rojas 1988). By 2004, the canton had 11 *beneficios*, four of which were cooperatives (Fernández & Alvarez 2004). The three new *beneficios* each processed less than 25,000 *fanegas* of coffee, with two of them processing less than 1,000 *fanegas* each in the 2003-04 harvest (ICAFE 2005a). One of these latter two was a women's processing and roasting cooperative called the Asociación de Mujeres Organizadas de Biolley (Montoya 2003), and the other was an estate called Cafetales Lila, which processed and roasted its own coffee (ICAFE 2005c).

According to Arnaldo López, president of ICAFE in 1992, Coto Brus is unique in that its coffee is the first in the country to ripen, the industry is composed almost entirely of small farmers with an average of 4 ha of coffee each, and the *cantón* is almost entirely dependent on coffee activity (Viquez 1992b). In 1984, more than 82% of the *cantón's* 3,179 farms grew coffee, and coffee accounted for 99.8% of the area planted in permanent crops (DGEC 1987). In the past, many children have had to leave school

* General Director of Coopabuena, a coffee processing cooperative in Agua Buena, 2003.

during the harvest, contributing to the area's relatively low educational level (Zeledón 1987).

Coffee farming in Coto Brus suffers from a high incidence of fungal diseases, and relatively poor dissemination of technical information to coffee growers (Rojas 1988). As a result, yields in Coto Brus are the second lowest in Costa Rica (after Pérez Zeledón), averaging 24.8 *fanegas* per hectare from 2000-02, or 13.6% less than the national average of 28.72 *fanegas* per hectare (Fernández et al. 2002 p. 22). Processing yields are the third lowest of Costa Rica's eight coffee regions, averaging 90.8 pounds of green coffee per *fanega* during the 2003-04 harvest, 4.1% lower than the national average of 94.81 (calculated from Fernández & Alvarez 2004). For the 2001-02 harvest, Coto Brus ranked third of seven coffee-growing regions in terms of total production (Fernández et al. 2002 p. 23).

The price paid to farmers for ripe coffee cherries is also the second lowest in the country, averaging \$48.35 per *fanega* for conventional coffee, and ranging from \$34.06 to \$92.10, influenced in part by altitude and whether the coffee berries are ripe, (calculated from ICAFE 2005c), compared to a mean of \$59.39 nationally (calculated from Fernández & Alvarez 2004). The lower price can partly be explained by the low processing yields. While the price paid to farmers per *fanega* is 18.6% lower in Coto Brus than nationally, the price with processing yields taken into account is only 7.9% lower, or \$0.58 per pound of green coffee in Coto Brus compared to \$0.63 per pound nationally. Another reason for the lower prices is that the roads in the southern zone of Costa Rica are the worst in the country (Quesada & Marín 2001), making it more difficult, and expensive, to bring products to market (L. Sanchez, pers. comm.).

Gilberto Gutiérrez, director of FEDECOOP in 1992, reported that Coto Brus was one of four cantons in Costa Rica most hard hit by the current crisis (the other three were San Carlos, Sarapiquí and Turrialba), primarily as a result of the forgoing factors. Compounding matters, in October 2001, Hurricane Michelle made many roads impassable and caused *recibidores* to shut down, resulting in a loss of 30% of the harvest that year (Quesada & Marín 2001).

Land

The reduction of coffee area by the turn of the century was most severe in Coto Brus, Pérez Zeledón and Turrialba (Brenes 2002). Gilberto Gutiérrez had estimated that, as early as July 1992, as many as half of Coto Brus coffee farmers had left their farms, primarily to migrate to banana-growing regions (Viquez 1992a). Ten years later Henry Rojas, director of ICAFE for the Brunca region, reported that 1,089 farms in the southern zone had been abandoned, and 400 converted to other uses. Rojas said that most of these conversions had been to cattle pasture, as farmers had little money to invest (Valverde 2002). Sugar was another popular choice for conversion (Brenes 2002).

Labor

Despite the abandonment of coffee farms and the changeover to other crops, the net rate of migration into Coto Brus remained positive throughout the 1990's, albeit at a much lower level than in earlier decades. The net annual rate of migration into Coto Brus was 10.3% for the period from 1968 and 1973, dropping to 2.4% from 1979 to 1984, and to 1.5% from 1995 to 2000. The population of the Southern Zone (the cantons of Pérez Zeledón, Buenos Aires and Coto Brus) reached its peak as a percentage of Costa Rica's population in 1973, at 11%, before declining to 9% by 2000 (Barrantes & Pana 2005).

Technology

The reduction of inputs was more dramatic in Coto Brus than elsewhere. Between 1990 and 1995, the number of coffee producers in Coto Brus who applied fertilizer to their farms fell from 93.3% to 66.7%, a drop that was three times the national average (ICAFE 1993 p. 66).

In 2003, I obtained a list of all major agrochemical suppliers was from the ICAFE office in San Vito, and provided each supplier with a questionnaire regarding agrochemical sales over the past 10 years. Only two suppliers responded to the questionnaire. Both suppliers who replied were subsequently interviewed in person to obtain clarification and elaboration of their answers.

One supplier – the owner of a store in Cañas Gordas, on the border with Panama, had only been in business for 1½ years. He reported that the majority of his sales were to

farmers in Panama, and that sales had increased drastically after the mid-2003 closure of the supply store operated in nearby Coopabuena (two months before the interview). Locals reported that the Coopabuena supply store had closed due to financial insolvency. Because of the Cañas Gordas store's unique situation, and the relatively short period of time that it had been open, the results of that store's questionnaire cannot be considered typical and are not included here.

The second vendor owned a major agricultural supply store based in San Vito. He reported that the past several years had been "brutal." From gross sales of \$1.4 million in 1997 (reported as constant 2003 dollars), revenues dropped more than 74% over five years, to \$352,000 in 2002. Figure 2.3.1 shows his reported gross chemical sales from 1993-2002, plotted with coffee prices over the same period. He reported that sales of those fungicides, fertilizers and nematicides normally used in coffee had declined dramatically, while fertilizers and fungicides normally associated with annual vegetable crops, such as green pepper and tomato, had been increasing. Sales of herbicides had remained steady, with glyphosate gradually replacing Paraquat, and sales of Tordon^{*} on the increase. Herbicides are used with both coffee and annual crops in Coto Brus, but are also used in cattle pastures. Glyphosate is often applied after land clearing, to prepare the ground for pasture grasses, and Tordon is used to eliminate broadleaf weeds.

For this vendor at least, gross annual chemical sales were closely correlated with the price of coffee paid to farmers in the same year ($N=10$, $r=0.719$, $p=0.019$). Although no other suppliers responded to the questionnaire, anecdotal reports and personal observations support the inference that this San Vito supplier's experience is typical of what was happening to other agrochemical suppliers in the *cantón*. No information was obtained regarding relative quantities of chemicals sold.

^{*} 2,4-D Picloram

Figures

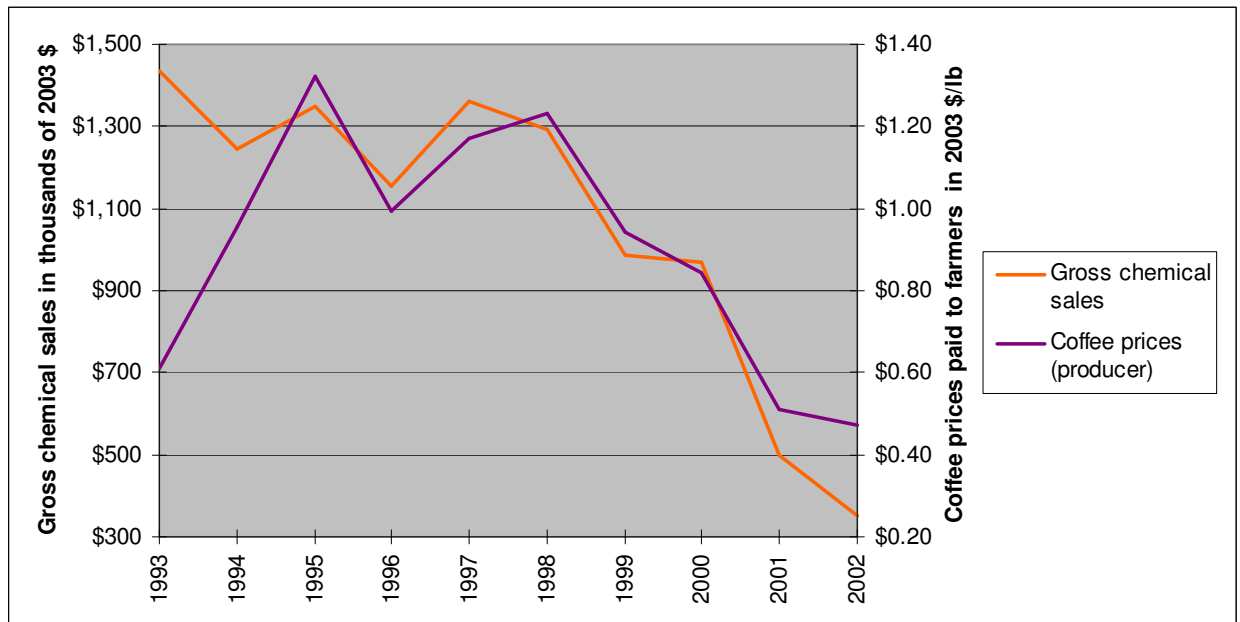


Figure 2.3.1. Gross sales, in 2003 US dollars, of agrochemicals at a major supply store in San Vito, Coto Brus, from 1993-2002, and average prices paid to farmers in Costa Rica, expressed as 2003 US dollars per pound of green coffee equivalent. Data from ICAFE (1997), ICAFE (2005c), Ferndandez et al. (2002), and ICO (2005b). Inflation data from U.S. Dept. of Labor (2004).

4. *Agua Buena and Individual Households*

Agua Buena is the southernmost and smallest district in the *cantón* of Coto Brus, encompassing 6,118 hectares (Sandoval 2002) on the border with Panama. The population of Agua Buena nearly doubled between 1973 and 1984, climbing 72.9% from 3,729 to 6,446 residents, at which point the population nearly leveled out, rising only 8% between 1984 and 2000, reaching a population of 6,962 (DGEC 1974; MGP 1986; INEC 2001). The district is considered by the Costa Rican Institute of Statistics and Censuses to be 100% rural (INEC 2001).

Literacy and educational rates in Agua Buena have historically been slightly lower than the rest of the *cantón*, but had caught up with or exceeded the *cantón*-wide average by 2000 (MGP 1986; DGEC 1974; INEC 2001). Comparative income data were only found for 1973, when the median annual income was 7.9% below the canton average, and 42.2% below the national average, at \$3,350 (expressed as 2003 dollars) (DGEC 1974). In 2000, 54.75% of homes in Agua Buena had at least one area of critical shortage, compared to 36% for the country as a whole. Shortage areas, as defined by the Instituto Nacional de Estadística y Censos, include access to adequate shelter, food, potable water, sanitation, clothing, and primary and secondary education (Solórzano & Fonseca 2005).

The area has been converted in the past 50 years from mostly undisturbed forest to a patchwork of small farms (Manger 1992). Currently, small patches of forest remain throughout the area, primarily around streams, and living fences are the preferred method of marking boundaries between properties or cultivation areas. Like the rest of Coto Brus, Agua Buena has historically been economically dependent on coffee production. In 1984, 1,134 hectares, or 28.6% of Agua Buena's 3,969 hectares of farmland, were devoted to coffee (DGEC 1987). In 1984, another 44.8%, or 1,778 hectares, of Agua Buena's farmland was devoted to cattle pasture, supporting 2,960 cows (DGEC 1987). By 2000, the area planted with coffee had decreased 15.7%, to 956 hectares (Sandoval 2002).*

* No data on extent of cattle pastures are currently available for 2000.

In 2003, most of the *recibidores* in the District belonged to Paso Real, a private *beneficio*, or Cooperativa Agua Buena (“Coopabuena”), the area’s coffee cooperative. During the 2003-04 harvest, Coopabuena paid an average of \$53.70 per *fanega*; with processing yields of 89.57 pounds/*fanega* (Fernández & Alvarez 2004). This represents \$59.95 per 100 pounds of green coffee (known as a *quintal*), and is 13% above the *cantón*-wide average of \$52.93 per *fanega*, and 1% above the national average of \$59.39. The higher prices paid to Coopabuena farmers may be a result of the cooperative’s participation in two fair trade programs (Coocafe and a direct marketing program), through which, according to former U.S. interns at Coopabuena, Coopabuena marketed approximately 10% of its coffee from the 2003-04 harvest (Grosser et al. 2005).

Staff at Coopabuena reported having repossessed approximately ten farms over the past ten years, of which seven were repossessed as a result of bad debt. When asked about changing population levels in Agua Buena, they responded that the population was “a little bit critical,” due to the price of coffee and the devaluation of the national currency. The staff expressed fears that Coopabuena and environs could become a “ghost town” due to the declining interest in coffee farming. These fears appear to have been well-founded, as Coopabuena closed its doors after the 2003-04 harvest (Barquero S. 2004e; 2005; ICAFE 2005c).

Observations of the landscape in and around Agua Buena, and informal discussions with farmers, led to the formulation of two main hypotheses to be tested to examine the effects of the coffee crisis in Agua Buena from the socioeconomic and environmental perspectives:

H1. Coffee farmers faced with low prices are choosing to convert their farms to other uses, and the predominant conversion choice is cattle pasture.

H2. Coffee farms that had been converted to cattle pasture would show a lower bird diversity and richness than coffee farms that had not been converted.

The methods and results for each hypothesis are explained and discussed separately below.

H1: Individual farmer decisions

Hypothesis: Coffee farmers faced with low prices are choosing to convert their farms to other uses, and the predominant conversion choice is cattle pasture.

Methods

Sixty farmers in Agua Buena were interviewed to assess land use decision-making and related economic factors. The interviews were carried out in respondents' homes by one of two interviewers, with the exception of one respondent who, at the respondent's request, was given the question sheet for review prior to the interview, and returned later with written answers to the interview questions. A pilot survey instrument was administered to three respondents, then modified slightly, with additional questions, for the remainder of the respondents. Follow-up interviews were conducted with two of the three pilot respondents to collect additional data that had been added to the final survey (available in Appendix A). In addition to questions about land use and farm practices, respondents were asked questions about socio-economic background and environmental perceptions. After the main interview, farmers were also asked to answer additional questions regarding costs of production. Four farmers agreed to answer these additional questions.

Interviews were conducted in the immediate environs of Agua Buena, in the center of town and following roads out as far as 2.5 km from the main plaza, in the directions of the towns of Campo Tres and Cañas Gordas and the barrios of San Miguel and Santa Marta. Interviews were solicited by knocking on doors or approaching farmers in the field. The interviews were then either carried out immediately or scheduled for a time convenient to the farmer. If no one was home at the first visit, the house would be re-visited once to try and find someone at home. All houses in the survey area were approached, but only farmers who currently or formerly grew coffee and were the primary decision-makers for the land they cultivated were interviewed. No one who was found at home refused to answer these two initial qualifying questions. Three farmers who met the criteria for the interviews declined to be interviewed, for a response rate of 95.2%.

Excel 2003 was used to calculate totals, means, and ranges of data. SPSS 10.0.5 was used to calculate medians and modes and to perform *t*-tests, Pearson's *r*, χ^2 and

Fisher's Exact Test. For t -tests, where Levene's test for equality of variances was significant at $p < 0.05$, the t statistic with equal variances not assumed was used. In all statistical tests, α was tested at 0.05.

One interview was excluded from the analysis because the respondent was an employed caretaker for an absentee landowner, and was not the primary decision-maker for the farm. Additionally, six other questions are partially or wholly excluded from the analysis, due to possible interviewer bias or other confounding variables (for an explanation see Appendix A).

Results and Discussion

Demographic, social and economic background of sample

See Table 2.4.1, Table 2.4.2, and Table 2.4.3 for summaries of the survey responses. The mean household size was 3.9 people. Seven (12%) of the respondents were female, and 52 (88%) were male. Only 6.8% of respondents were single, with 81.4% married, and 11.9% widowed or divorced. On average, respondents had lived the region for 28.3 years, with 1975 the median year for arriving, by immigration or birth, in the region. The mean number of years of schooling was four, with the median being three years (the mean was influenced by one outlier, a single respondent who had attended university).

All but one of the respondents owned their land outright. The total land area owned was 501.65 ha, or 99.9%, and the total area rented was 0.7 ha, or 0.1%. Two-thirds of survey respondents had purchased their land, while just over a quarter had inherited it. One respondent acquired their land by trade, one acquired it by marriage, and another acquired it through a government program to encourage settlement in the region.

Most respondents did not know their annual income. To arrive at an estimate, the interviewer would ask questions regarding specific sources of income and amounts received from each, including government pensions and remittances from family members, and combine those data with information provided regarding the latest coffee harvest. The annual household income for the sample, calculated based on this data, averaged \$4,133, or \$1,060 per capita, with a median of \$1,784 and a range from \$360 to

\$26,500. Respondents reported ten categories of additional, non-coffee income, of which six were on-farm and four were off-farm. In all, nineteen respondents (32.2%) cited additional on-farm sources of income, and 37 (62.7%) reported off-farm sources, with seven (11.9%) reporting both. Of those farmers who still grew it, coffee accounted for, on average, 52.9% of total income. Nine respondents, or 15.3%, of respondents reported using credit to pay the costs of production.

Farming practices and coffee production

The total land area managed by the respondents was 502 hectares. In total, the survey respondents reported producing a total of 39 different products on their farms, with a mean of 5.4 products per farm (a full list of farm products reported is available in Table A.3 in Appendix A). Coffee growing was significantly correlated with the total number of products produced on the farm, with farmers who still grew coffee producing, on average, 6.1 products, and farmers who no longer had coffee producing an average of 3.5 products ($t=3.047$, $df=50.195$, $p=0.004$).

Most farmers did not belong to agricultural organizations, with 21 farmers (35.6%) reporting membership in a coffee cooperative and three (5.1%) reporting membership in another type of agricultural organization (a dairy marketing association, a plantain association, and a regional agricultural association). Of those who reported membership in an organization, the mean number of meetings attended per year was 2.63, with a median of one meeting per year (usually their cooperative's annual assembly).

The mean number of workers on respondents' farms outside the harvest was 1.4, with a mean of 1.1 family member (usually the respondent him- or herself or a son) and 0.3 paid workers. Most farms only had one worker: the respondent. The maximum number of year-round workers on a respondents' farm was six, with four paid workers.

Thirty-three respondents (55.9%) reported currently using various agrochemicals. More information on the types of chemicals used is available in Table 2.4.2. Many of the other respondents reported that they used chemicals in the past. Of the 41 farmers who

still grew coffee, eight of them, or 19.5%, planned to convert to growing organic or “sustainable”^{*} coffee.

The mean price received at the last coffee harvest was \$35.59 per *fanega*, ranging as low as \$26.88 and as high as \$48.87 – all values well below the mean of \$66.05 reported as the price that coffee would need to reach to be profitable, and the mean of \$82.03 that it would need to be worthwhile to grow. Yields ranged from 2.5 to 64.0 *fanegas* per hectare, with a mean of 16.8 and a median of 15.0. The mean total harvest was 43.0 *fanegas*, resulting in a mean gross income from the last coffee harvest of \$1,530. A plurality of sixteen respondents (27.1%) reported 1997 or 1998 as the year of the highest price they could remember. This corresponds with the peak prices for the 1990’s, but only six respondents (10.2%) reported a year prior to the expiration of the International Coffee Agreement, and only one respondent reported 1977, which saw the highest worldwide export prices in at least the past 40 years.

Four farmers responded to an additional survey regarding costs of production. This survey included information about labor costs, input costs, replanting costs and property taxes, and did not assign a cost to labor provided by the respondent or his or her family – i.e., only paid labor was given a cost. Unlike the ICAFE costs of production model (Portilla R. & Araya M. 2002), the survey instrument did not take into account depreciation and replacement costs of items such as tools, equipment and buildings.

Mean production costs for these four respondents were \$18.53 per *fanega*, or \$280.09 per hectare. Given the prices that these respondents reported for their last harvest, the mean profit came to \$18.34 per *fanega*. With the yields reported by these respondents, the mean profit per hectare was \$276.96, for a total mean net income (taking into account farm size and total harvest) of \$588.59 (gross income \$1,425.63, expenses \$837.04). The mean gross annual income for this group was \$2,822.00, meaning that, on average, the respondents spent 29.7% of their annual income on the costs of production for their coffee. Gross revenues from coffee, in turn, provided an average of 50.5% of

^{*} A category of coffee established by ICAFE, involving a flexible scoring system for environmental and social responsibility, based on the Starbucks “C.A.F.E. Practices” procurement standards. ICAFE has proposed a price premium of US\$5 per *fanega* for sustainable coffee.

respondents' gross income. Because of the small sample size (N=4), care should be taken in making generalizations from these data.

Coffee removal

Forty-five respondents, or 76.3%, had removed at least some of their coffee in the preceding six years, with a total of 126.2 hectares, or 56.9%, of coffee removed. Of the 59 respondents, 41 (69.5%) still grew at least some coffee, and eighteen farmers (30.5%) no longer grew any coffee at all. Of the 45 respondents who had removed some coffee, 42, or 93.3%, listed low prices as a reason for their decision. Other factors listed were the high costs of production (15.6%) and large amount of labor (13.3%) required by coffee, problems with diseases or pests (6.7%), and the age of the coffee trees (6.7%).

Of those who still grew coffee, thirteen (35.1%) of 37 respondents who answered said that they planned to reduce their coffee further in the near future, and eleven (29.7%) said that they would do so if the price of coffee did not increase. Only thirteen respondents (35.1%) said they definitely planned to continue growing coffee.

The relationship between the decision to remove coffee, and the decision to keep some coffee, with other economic, social or demographic variables was tested using, as appropriate, χ^2 , Fisher's Exact Test, and *t*-tests. Several variables showed a significant relationship with either previous removal of coffee or whether the respondent still grew any coffee at all.

The first of the associated variables was gender, with men almost twice as likely (80.8%) as women (42.8%) to remove coffee (Fisher's Exact Test, $p=0.048$). The next correlated variable was original extent of respondents' coffee area. Farmers who removed coffee started off with nearly twice as much coffee, on average, as those who did not (4.2 vs. 2.5 ha, $t=2.456$, $df=51.172$, $p=0.017$). Use of credit was significantly associated with whether respondents still grew some coffee, with 22.5% of coffee growers, and 0.0% of non-coffee growers, using credit (Fisher's Exact Test, $p=0.048$). Membership in an agricultural association was also significantly associated with whether a respondent still had coffee. Of those who still had coffee, 60.5% were members of an association, while only one respondent, or 5.6%, of those who did not have coffee belonged to one (Fisher's Exact Test, $p=0.000$).

For respondents interviewed by the Costa Rican interviewer, the price required to make coffee worthwhile to grow was significantly correlated with whether or not a respondent still grew at least some coffee. Respondents who still grew coffee desired a higher price (\$84.71/*fanega*) than those who did not (\$73.31/*fanega*, $t=3.452$, $df=18$, $p=0.003$).

Farmers who used wood as a fuel source were significantly less likely to have removed their coffee than farmers who did not use wood (65.8% compared to 95.0%, Fisher's Exact Test, $p=0.011$). Whether or not respondents still had any coffee left was also associated with use of wood as a fuel source, with 77.5% of respondents who still had coffee using wood, and 38.9% of respondents who did not have coffee using wood (Fisher's Exact Test, $p=0.007$).

The final variable correlated with coffee removal was respondents' belief regarding what percentage of the bird species on their farms lived solely in the forest, as opposed to cropland or a combination of cropland and forest. Farmers who had removed coffee believed that, on average, 56.0% of birds lived only in the forest, while farmers who had not removed coffee believed that no bird species lived only in the forest ($t=3.162$, $df=8$, $p=0.013$).

Land use and population change

The vast majority of respondents (86.4%) reported that at least one family member had left the community, and of those respondents, 82.4% listed economic reasons as being at least one factor in their family members' decisions to leave. Ten respondents (16.9%) reported that they planned to leave the community themselves, with six of those ten respondents (46.2%) saying they would sell their land, and four of the ten (30.8%) hoping to immigrate to the United States.

One interview had to be excluded from the analysis of land use questions involving quantitative land areas, as the respondent did not provide data on the critical question of how much coffee he had prior to conversion to pasture. The total land area represented after this respondent was removed was 457.1 hectares. Land uses on the other respondents' farms were classified into several broad categories: coffee, pasture,

forest (primary and secondary), abandoned or charral,* and other crops. All land use data for the respondents are summarized in Table 2.4.4. At the time of the survey, a total of 20.9% of the land area managed by respondents was planted in coffee, 47.4% was used for pasture, 7.2% was planted in other crops, and 22.7% was not currently in use for agriculture (i.e. either abandoned, charral, or forest).

Forty-five respondents, or 76.5%, had removed at least some of their coffee in the preceding six years, with a total of 126.2 hectares, or 56.9%, of coffee removed. At the same time, the total land area in pasture and other crops (such as plantain, tomato and peppers), increased by 81.2 and 19.3 hectares, respectively. These changes represented increases of 59.9% and 140.4% over their original extent. Seventeen hectares were abandoned, an increase of 186.3% in abandoned area. In all, the coffee removed represented 27.4% of the total land area managed by the respondents, with the replacement uses of pasture, other crops, and abandoned land representing 17.6%, 4.2%, and 3.8%, respectively, of the total land area, and 64.3%, 15.3%, and 14.0%, respectively, of the 126.2 hectares of coffee removed. Figure 2.4.4 shows the land uses, by percent of land area, to which respondents converted their coffee.

Based on information given in the interviews about previous land use and future plans for the land, estimates were calculated for land use six years prior to the interviews, and for planned future land use. Figure 2.4.1, Figure 2.4.2, and Figure 2.4.3 show graphical depictions of these values, showing total land use at different points in time. Figure 2.4.5 shows land use changes as a percent of total area.

Discussion

The survey respondents appear to provide a representative sample for the area. By summing the reported household sizes of the respondents, it can be determined that the sample represents the households of 233 individuals living in Agua Buena, or 3.3% of the 6,962 people living in the district as of the 2000 census. The mean of 3.9 persons per household was very close to the district-wide average in 2000 of 4.0 INEC (2001). The gender composition of the sample is very close to the results of the *Censo Cafetalero*

*Pasture in a state of recent abandonment or overgrowth, characterized in the Agua Buena region by mostly woody vegetation averaging 1-2 meters in height; potentially an early stage of forest regeneration.

(INEC 2004), which found that 91.2% of coffee farmers in Coto Brus were male, and 8.8% were female.

The age profile for respondents was a great deal older than the census profile for Coto Brus as a whole (Figure 2.4.6), but much more closely resembled the profile from the *Censo Cafetalero* (Figure 2.4.7). Data from both censuses could not be plotted together, as the 2000 Census and 2003 *Censo Cafetalero* used different age groupings. Since many respondents noted that their sons helped them with the farms, this age distribution probably reflects land tenure practices, with land ownership and decision-making responsibilities resting with the older family members. The amount of time that respondents had lived in the region corresponded closely to the 1968-1973 peak of migration into Coto Brus (Barrantes & Pana 2005).

When grouped by educational level (Figure 2.4.8, with respondents who had less than a year of schooling grouped with the “none or kindergarten only” group), the survey responses for education match closely those in the *Censo Cafetalero*. The *Censo Cafetalero*, which covered the *cantóns* of Coto Brus and Turrialba, does not break down education data by region, and therefore those statistics are aggregates for both regions. When compared to the 2000 census data from Agua Buena, both the survey responses and the *Censo Cafetalero* show a greater percentage in the “primary” category, and fewer in the “secondary” and/or “post-secondary” category, possibly indicating that coffee farmers have had less access to education than the general population. This may also be affected by the comparatively greater percentage of coffee farmers in the “60 and up” age category, as educational opportunities improved for the country as a whole throughout the second half of the 20th century.

The 99.9% of land that was owned, rather than rented, by the respondents is similar to the *Censo Cafetalero*, in which 96.4 % of the surveyed land area in Coto Brus was owned. The mean income for the respondents of \$4,163 is distorted by two high outliers of \$26,500 and \$18,790, thus the median of \$1,784 may be more informative. This places at least half the sample at or below the mean income of the lowest income quintile nationwide (INEC 2003b). When the two outliers are removed, the mean household income for the sample drops to \$2,976, or \$714 per capita. Nationwide, as of

July 2003, the mean household income was \$7,668 annually (INEC 2003b), or \$1,987 per capita.

Annual household income for respondents who reported other income besides coffee was higher, on average, than those who did not (\$4,204 vs. \$3,000), but due to the low number of respondents (two) that did not report other sources of income besides coffee, this difference could not be statistically tested. Furthermore, with the two outliers mentioned earlier removed from the analysis, the means for the two groups are nearly identical (\$2,974 for respondents with other sources of income, \$3,000 for respondents without). Due to the difficulty in assessing all income sources, it is likely that many respondents underreported income.

Only a small percentage (15.3%) of respondents reported using credit to pay the costs of production. This is in stark contrast to the *Censo Cafetalero* (INEC 2003a), in which 72.4% of farmers in Coto Brus reported using credit. The interview responses showed no relationship to interviewer (Fisher's Exact Test, $p=0.132$), so the discrepancy with the census is probably not due to respondents being more or less willing to disclose credit use to a North American interviewer, or by a different phrasing of the question.

The difference could be the result of differences in credit use by district not elucidated in the *Censo Cafetalero's* aggregate data for Coto Brus, collected in the same year as the interviews. That is, it may indicate that farmers in Agua Buena have less access to credit than farmers in other parts of the *cantón*, possibly due to being relatively further from banks and large, financially stable coffee processors. Many respondents reported that they used to use credit, but that it was no longer available. In August 2004, the Costa Rican daily newspaper *La Nación* reported that Coopabuena's critical financial situation was forcing it to restrict credit to its members (Barquero S. 2004a).

Of those respondents who still grew coffee, only thirteen respondents (35.1%) said they definitely planned to continue growing it, with the rest saying that their decision was contingent on the future price of coffee. Therefore, given that the price of coffee has not substantially increased since the interviews were conducted in 2003, it is possible that as few as 13, or 22.0%, of the original 59 coffee farmers interviewed, are still growing coffee today. Despite the desire of these thirteen respondents to continue growing coffee,

this number could even be much lower, given the closure of Coopabuena after the 2003-04 harvest.

The correlation between original extent of coffee and coffee removal may be explained by the fact that, because larger coffee farms require the use of paid labor, costs of production are often higher for larger farms. These higher costs may have impacted the decisions of respondents to either remove their coffee or decrease it to a more manageable area. In the costs of production survey, costs of production per hectare and per *fanega* were positively correlated with farm size, though not significantly so (per hectare: $r=0.328$, $p=0.672$; per *fanega*: $r=0.594$, $p=0.406$).

Due to the small sample size ($n=4$) in the costs of production survey, however, the power to separate these groups is extremely low: given an expected r of 0.594 between farm size and costs of production per *fanega*, there is an approximately 10% chance of detecting a correlation at $p<0.05$ (Dunlap 1981). It may also be that respondents with more land perceived more options for diversification or changeover of crops: for example, it is easier to sustain cattle given a larger area of pasture.

The correlation between credit use and whether respondents had coffee probably indicates that coffee growers either have a greater need for credit than non-coffee growers, or that they have greater access to credit, most likely through *beneficios* (respondents were not asked whether they used credit for coffee or for other crops). The correlation between maintaining coffee and membership in an agricultural organization is to be expected, since the cooperative coffee *beneficios* are the predominant agricultural associations in the region.

The use of wood as a fuel was significantly correlated with coffee removal. Rather than use of wood as fuel being predictive of a propensity to keep growing coffee, it is likely that farmers who removed coffee subsequently had less access to fuel wood, and therefore had a greater incentive to switch to alternative fuels such as gas or electricity. This is supported by responses to other interview questions: of farmers who still used wood and still grew coffee, 57.9% said that they did not expect to have enough wood for fuel if they removed more coffee, and 26.7% said that they would change to another fuel source.

Several of the statistically significant relationships between coffee removal and other variables are compromised by small sample size in one or more groups. These are the correlations between coffee removal and gender (n=7 for women), price needed for coffee to be worthwhile to grow (n=5 for those who no longer had coffee), and respondents' belief regarding what percentage of the bird species on their farms lived solely in the forest (n=2 for farmers who had not removed coffee). Caution must therefore be used in trying to draw generalizations from these data. The correlation between coffee removal and price desired for coffee, however, may indicate that farmers who maintained their coffee are willing to tolerate lower prices than those who removed it.

Apart from the seven variables discussed above, no other significant relationships were found between coffee removal and any other variable tested in the interviews. It appears, therefore, that the only factor that could be predictive of a decision to change from coffee to another land use is the size of the original land area of coffee. Additionally, with the likely exceptions of fuel wood use, the data do not support any conclusion that removal of coffee has had any statistically significant effect on any of the other variables surveyed. Whether a farmer has retained some coffee, however, appears to have an effect on their use of both fuel wood and credit, on their membership in agricultural associations, and on the minimum price they believe they would need to receive for coffee production to be worthwhile.

Planned future land uses (Table 2.4.4, Figure 2.4.3, Figure 2.4.5) should be viewed with skepticism. They do not take into account respondents' plans to leave the area or sell their land, unless the respondent mentioned this explicitly as part of their plans for their land. Respondents who expressed a desire to convert abandoned land into other crops, or to renovate charral into working pasture - resulting in the predicted drop in the "abandoned/charral" category - may not have actually had access to the resources to do so. Likewise, some farmers may not have had the resources to carry out a hoped-for conversion from coffee to another crop, and farmers who planned to sell their land may have had difficulty finding a buyer, resulting in land abandonment.

The “planned” land use category, therefore, only represents a desired or expected state of affairs in the minds of the respondents at the time of the interviews, and not necessarily a realistic future outcome. It does demonstrate, however, the inclination of respondents to reduce coffee production further, and expand pasture and other crops.

Conclusions

The results of this survey support H1, which states “Coffee farmers faced with low prices are choosing to convert their farms to other uses, and the predominant conversion choice is cattle pasture.” The 76.3% of respondents who reported having removed coffee represent a clear majority of the sample ($CI_{95\%} = 65.4\%-87.2\%$), supporting the hypothesis that farmers are choosing to convert their farms to other uses. The hypothesis that conversion is a response to price is supported by the 93.3% of farmers reducing coffee who listed price as a motivating factor ($CI_{95\%} = 86.9\%-99.7\%$).

Finally, the hypothesis that the predominant conversion choice was pasture is supported by the fact that 64.3% of the total land area converted from coffee was replaced by pasture. At the level of individual respondents, however, the trend is less clear-cut. The mean percent, by farm, of former coffee area converted to pasture was 46.1% ($CI_{95\%} = 31.5\%-60.7\%$). This shows that, while a majority of farmers may not be choosing pasture as the main replacement for coffee, those farmers who are represent a larger proportion of land ownership, with the net result that most of the lost coffee area has been converted to pasture.

Fifteen percent of the land converted from coffee was planted with other crops, predominantly plantain, tomato and peppers. The vast majority of these other crops were more chemically intensive than coffee, based on reports from respondents themselves, neighbors, and agrochemical suppliers. A comparative analysis of the quantities and toxicities of chemicals used in conventional coffee and the crops that have replaced it could help elucidate the environmental impact of this aspect of land conversion.

The conversion from coffee to other land uses was accompanied by a statistically significant decrease in agro-biodiversity, as represented by the reduced average number of products per farm (from 6.1 to 3.5). This can be accounted for, in part, by the fact that coffee represents one of the products lost. Additionally, low-growing crops, such as

yucca, beans and corn, which are frequently interplanted with coffee, are not appropriate for planting in pastures. Orange trees are frequently cut down during the conversion from coffee to pasture. It is also possible that the higher number of crops is indicative of diversification on the respondents' farms prior to conversion, which may indicate that more diversified farmers were more inclined, or more able, to keep growing coffee.

The interview responses yield other important information regarding the direct and indirect environmental effects of the coffee crisis in the region. Twenty percent of respondents who used wood as a fuel source reported that, if they removed all their coffee, they would seek firewood elsewhere - either by collecting from other properties or by purchasing it. Another 40% reported that they did not know, or had not thought about, what they would do for fuel. These responses indicate that coffee removal is likely to lead to additional pressure on what remains of the area's forest fragments.

The large numbers of family members reported as leaving the region, the ten respondents (16.9%) who planned to leave the community themselves, and the 14.0% of coffee land that was abandoned, indicate that land abandonment is another trend in the region that can be expected to grow in light of continued low prices. The rate of population increase in the area has been very low since the mid-1980's, coming close to leveling out by the turn of the century. Although many interview respondents had plans to expand crop production or renovate pasture, the simple fact is that many do not have the resources to do so.

Some farmers who wanted to sell their land reported difficulty finding buyers, and farmers who wanted to stop farming in order to find paid work for themselves often could not find jobs. The closure of the Paso Real and Coopabuena *beneficios* almost certainly had dramatic effects on the ability of the area's population to sustain itself. While seeking interviews, interviewers heard stories of farmers borrowing large sums of money to pay *coyotes** to help them enter the United State for work, and when they could not pay back the loan, their land was repossessed by the lender (often the *coyote* himself). Frequently, repossessed land was simply abandoned. One woman described watching the coffee berries ripen and fall off the branches of the coffee trees on what used to be her

* Someone who transports or arranges transport of persons to the United States, usually illegally.

husband's farm, as the *coyote* who had repossessed the farm apparently had no interest in harvesting them.

It may seem that land abandonment could have a positive effect on the biodiversity of the immediate area around Agua Buena, by allowing secondary regeneration of forests – and indeed, many interview respondents reported that, although animal populations had declined since they first moved to the region, many species were starting to rebound. It should also be considered, however, that migration to cities is accompanied by its own set of environmental problems. When the larger scale is considered, the environmental impacts of urbanization resulting from land abandonment could offset some benefits resulting from the regeneration of secondary forests on the abandoned land. Such a comparative analysis, however, is beyond the scope of this work.

In short, three main responses to the coffee crisis revealed themselves during the course of the interviews: out-migration from the district, land abandonment, and conversion of land to pasture and other crops. Some of the environmental effects of conversion to pasture are examined in the following chapter. The effects of conversion to other crops is not examined in detail, though a hypothesis that this type of land use change is environmentally detrimental would be likely to be supported based on relative levels of agrochemical use and reduction in agro-biodiversity. Finally, out-migration and land abandonment is likely to have mostly positive environmental (though not social or economic) effects in the immediate area, but likely negative environmental effects on a larger scale, as emigrants move to cities.

Tables and Figures

Yes/No Questions	Yes	No	No answer/ Not applicable/ Don't Know
Spouse participated in interview	31 (52.5%)	18 (30.5%)	10 (16.9%)
Own their land	58 (98.3%)	1 (1.7%)	0 (0%)
Source of income besides coffee	49 (83.1%)	7 (11.9%)	3 (5.1%)
Use credit to pay farm costs	9 (15.3%)	47 (79.7%)	3 (5.1%)
If uses credit, lender requires them to use specific practices	9 (100.0%)	0 (0.0%)	0 (0.0%)
Want children to be farmers as well	18 (30.5%)	31 (52.5%)	10 (16.9%)
Member of agricultural association(s)	24 (40.7%)	32 (54.2%)	3 (5.1%)
Reported outside source of technical information	17 (43.6%)	20 (51.3%)	2 (5.1%)
Reported outside source of price information	24 (61.5%)	13 (33.3%)	2 (5.1%)
Has reduced coffee in the last 6 years	45 (76.3%)	14 (23.7%)	0 (0.0%)
Still grow coffee	41 (69.5%)	18 (30.5%)	0 (0.0%)
Plans to reduce coffee further (if they still grow coffee)	13 (31.7%)	13 (31.7%)	15 (36.6%)
Currently use agrochemicals	33 (55.9%)	21 (35.6%)	5 (8.5%)
Some family members have left the community	51 (86.4%)	7 (11.9%)	1 (1.7%)
Planning to leave the community themselves	10 (16.9%)	46 (78.0%)	3 (5.1%)
Use wood as a fuel source	38 (64.4%)	20 (33.9%)	1 (1.7%)
If they use wood, expect to have enough fuel wood if they remove their coffee	5 (13.2%)	22 (57.9%)	11 (28.9%)
If continuing with coffee, plan to change from conventional to sustainable or organic coffee	8 (19.5%)	16 (39.0%)	17 (41.5%)

Table 2.4.1. Summary of interview responses on yes/no variables.

Categorical Questions [*]		
Gender	Male	52 (88%)
	Female	7 (12%)
Marital status	Married	48 (81.4%)
	Single	4 (6.8%)
	Widowed/Divorced	7 (11.9%)
Means of acquiring land	Purchase	37 (62.7%)
	Inheritance	17 (28.8%)
	Government settlement program	1 (1.7%)
	Trade	1 (1.7%)
	Lease	1 (1.7%)
	Marriage	1 (1.7%)
	No answer	1 (1.7%)
Sources of income besides coffee	<i>On-farm</i>	Livestock 9 (15.3%)
		Vegetables 5 (8.5%)
		Plantain 7 (11.9%)
		Sugar Cane 1 (1.7%)
		Oranges 3 (5.1%)
	<i>Off-farm</i>	Family remittances 15 (25.4%)
		Work off-farm 19 (32.2%)
		Pension 5 (8.5%)
		Own business 4 (6.8%)
	No answer/No other income	10 (16.9%)
	Coffee cooperative	21 (35.6%)
	Other association	3 (5.1%)
	None	35 (59.3%)
Agricultural organizations of which they are a member		

Table 2.4.2. Summary of interview responses for categorical variables.

^{*} Not all percentages will sum to 100% for categorical questions, because some respondents listed several categories in their answers to some questions. All answers given are included in the tables.

Categorical Questions (continued)		
What was done with land that was formerly coffee	Pasture	25 (55.6%)
	Abandoned	10 (22.2%)
	Reforested	3 (6.7%)
	Other crops	17 (37.8%)
	Sold	2 (4.4%)
	Not specified	3 (6.7%)
Reasons for removal of coffee	Prices	42 (93.3%)
	Labor	6 (13.3%)
	Input costs	7 (15.6%)
	Pests/disease	3 (6.7%)
	Age of coffee	3 (6.7%)
	Other	6 (13.3%)
	Not specified	1 (2.2%)
Reasons for keeping coffee	Protect investment	3 (7.3%)
	Personal values or tradition	8 (19.5%)
	Hope for improvement in prices	12 (29.3%)
	No money for conversion	1 (2.4%)
	Small amount of land	3 (7.3%)
	Other	2 (4.9%)
	Not specified	15 (36.6%)
Reasons family members have left	Marriage	7 (13.7%)
	Economic reasons	42 (82.4%)
	School	7 (13.7%)
	Other	3 (5.9%)
	Not specified	4 (7.8%)
If thinking about leaving the community, what they would do	Sell land	6 (46.2%)
	Go to U.S.	4 (30.8%)
	Go to other part of Costa Rica	1 (7.7%)
	Don't know	2 (15.4%)
	Go wherever there is work	1 (7.7%)
If wood is used as a fuel source, and they are removing coffee, what they will do for fuel	Plant trees	7 (23.3%)
	Change fuel source	8 (26.7%)
	Buy wood	1 (3.3%)
	Collect wood elsewhere	5 (16.7%)
	Not specified/don't know	12 (40.0%)

Table 2.4.2. Continued.

Categorical Questions Continued		
Classes of chemicals used by those who use agrochemicals	Fertilizers	9 (27.3%)
	Foliar fertilizers	5 (15.2%)
	Fungicides	11 (33.3%)
	Herbicides	17 (51.5%)
	Nematicides	1 (3.0%)
	Organic fungicides (incl. copper)	5 (15.2%)
	Others	7 (21.2%)
Specific chemicals used by those who use agrochemicals	Atemi (Cyproconazol)	6 (18.2%)
	Counter (Terbufos)	1 (3.0%)
	Glyphosate	16 (48.5%)
	Lime	3 (9.1%)
	Mancozeb	1 (3.0%)
	Others	7 (21.2%)
	Paraquat	5 (15.2%)
	Silvacur (Tebuconazol + Triadimenol)	4 (12.1%)
Whether they believe there are fewer or more types and numbers of animals than when they first started with their farms	Tordon (2,4-D + Picloram)	3 (9.1%)
	Fewer	20 (52.6%)
	More	5 (13.2%)
	Same	12 (30.8%)
	No answer	2 (5.1%)

Table 2.4.2. Continued.

Quantitative Questions	Mean	Median	Minimum	Maximum	SD	No answer/ Don't know
Age (years)	54.3	54.5	26	89	16.6	1 (1.7%)
Education (years)	4.0	3.0	0	16	3.2	1 (1.7%)
Years in region	28.3	27.0	3	65	11.4	2 (3.4%)
Years with current land parcel	21.3	22.0	3	52	11.9	3 (5.1%)
Number of people in household	3.9	4.0	1	11	1.6	0 (0.0%)
Annual household income (dollars)	\$4,133	\$1,784	\$360.00	\$26,500.00	\$5,664	5 (13.2%)
Number of products produced from farm	5.4	5.0	0	17	3.7	0 (0.0%)
Number of association meetings attended annually (entire sample)	1.6	0	0	30	4.09	3 (5.1%)
Number of association meetings attended annually (association members)	2.63	1.0	0	30	5.99	2 (7.7%)
Percent of income from coffee (only farmers who still have coffee)	52.9%	54.0%	3.0%	100.0%	32.0%	3 (11.5%)
Number of workers on farm	1.4	1.0	0.0	6.0	0.97	0 (0.0%)
Number of family members who work on farm (including self)	1.1	1.0	0.0	3.0	0.64	0 (0.0%)
Number of paid workers on farm	0.31	0.0	0.0	4.0	0.71	0 (0.0%)
Amount of coffee removed by those who have removed some (hectares)	2.9	2.0	0.2	14.0	2.79	1 (2.2%)
Amount of coffee removed by those who have removed some (percent)	72.7%	83.3%	12.5%	100.0%	28.1%	1 (2.2%)
Number of years ago coffee removed	2.8	3.0	0.0	8.0	1.85	0 (0.0%)
Number of family members who have left the community	2.8	2.0	0	9	2.39	7 (11.9%)

Table 2.4.3. Summary of interview responses for quantitative variables.

Quantitative Questions (continued)	Mean	Median	Minimum	Maximum	SD	No answer/ Don't know
Price received for last coffee harvest (\$/ <i>faneqa</i>)	\$35.59	\$39.10	\$26.88	\$48.87	\$5.37	1 (2.1%)
Number of <i>faneqa</i> s harvested at last harvest	43.0	20.0	1.0	200.0	50.1	0 (0.0%)
Coffee yield at last harvest	16.8	15.0	2.5	64.0	10.8	2 (4.3%)
Price needed for coffee to be profitable (\$/ <i>faneqa</i>)*	\$66.05	\$61.09	\$36.65	\$112.40	\$15.09	3 (7.9%)
Price needed for coffee to be worthwhile to grow (\$/ <i>faneqa</i>)*	\$82.03	\$85.52	\$73.31	\$97.74	\$7.86	0 (0.0%)
Year of highest coffee price in memory	1995	1997	1977	2002	5	4 (6.8%)
Number of bird species believed to live on farm	23.2	17.5	0.0	200.0	30.5	5 (8.5%)
Percent of bird species believed to live in only forested areas of farms	45.5%	0.0%	0.0%	100.0%	52.2%	48 (81.4%)
Number of wild animals recognized on farm (which respondent was able to list by name)	10.7	9.5	0.0	51.0	7.8	7 (11.9%)

Table 2.4.3. Continued.

* These two variables are separated due to a difference in the wording between the Costa Rican and North American interviewer. See Appendix A for further discussion.

Current Land Use (hectares)	Mean	Median	Minimum	Maximum	SD	Total
Coffee	1.6	1.0	0.0	10.0	2.2	95.6 (20.9%)
Pasture	3.7	0.5	0.0	70.0	10.7	216.8 (47.4%)
Other crops	0.6	0.0	0.0	7.5	1.3	33.1 (7.2%)
Abandoned/charral	0.5	0.0	0.0	6.0	1.3	27.2 (6.0%)
Forest (primary or secondary)	1.3	0.0	0.0	50.0	6.9	76.5 (16.7%)
Not specified	0.1	0.0	0.0	3.0	0.5	8.0 (1.8%)
Total land area	7.9	3.0	0.2	112.5	17.1	457.1 (100%)
Land Use Prior to Conversion						
Coffee	3.8	3.0	0.0	15.0	3.3	221.8 (48.1%)
Pasture	2.3	0.0	0.0	56.0	8.8	135.6 (29.4%)
Other crops	0.2	0.0	0.0	7.5	1.1	13.8 (3.0%)
Abandoned/charral	0.2	0.0	0.0	5.0	0.7	9.5 (2.1%)
Forest (primary or secondary)	1.3	0.0	0.0	50.0	6.9	75.5 (16.4%)
Not specified	0.1	0.0	0.0	2.0	0.3	5.0 (1.1%)
Total land area	8.0	3.3	0.2	112.5	17.1	461.1 (100%)
Planned Future Land Use						
Coffee	1.2	0.0	0.0	10.0	2.1	69.2 (15.2%)
Pasture	4.2	1.1	0.0	70.0	10.8	241.0 (52.8%)
Other crops	0.7	0.0	0.0	10.0	1.7	43.0 (9.4%)
Abandoned/charral	0.3	0.0	0.0	6.0	1.1	17.5 (3.8%)
Forest (primary or secondary)	1.3	0.0	0.0	50.0	6.9	77.5 (17.0%)
Not specified	0.1	0.0	0.0	3.0	0.5	8.0 (1.8%)
Total land area	7.9	3.0	0.0	112.5	17.1	456.1 (100%)

Table 2.4.4. Summary of land use characteristics of the sample. “Planned Future Land Use” is land use if farmers carry out their plans for their land as disclosed to the interviewer, in light of continued low prices.

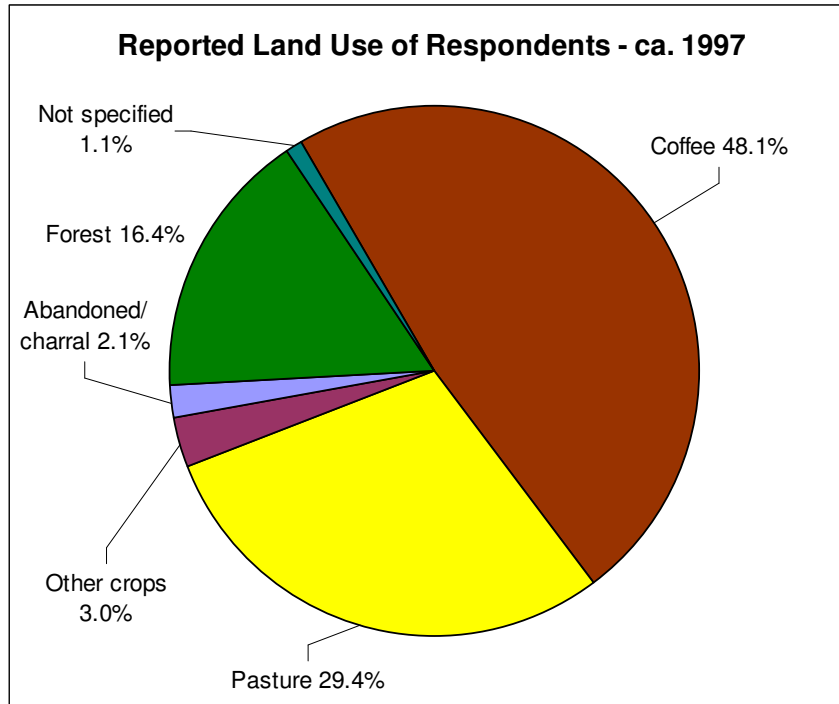


Figure 2.4.1. Estimated land use of sample circa 1997, based on reports of land use changes in the six years prior to interviews. Total land area represented is 461 hectares.

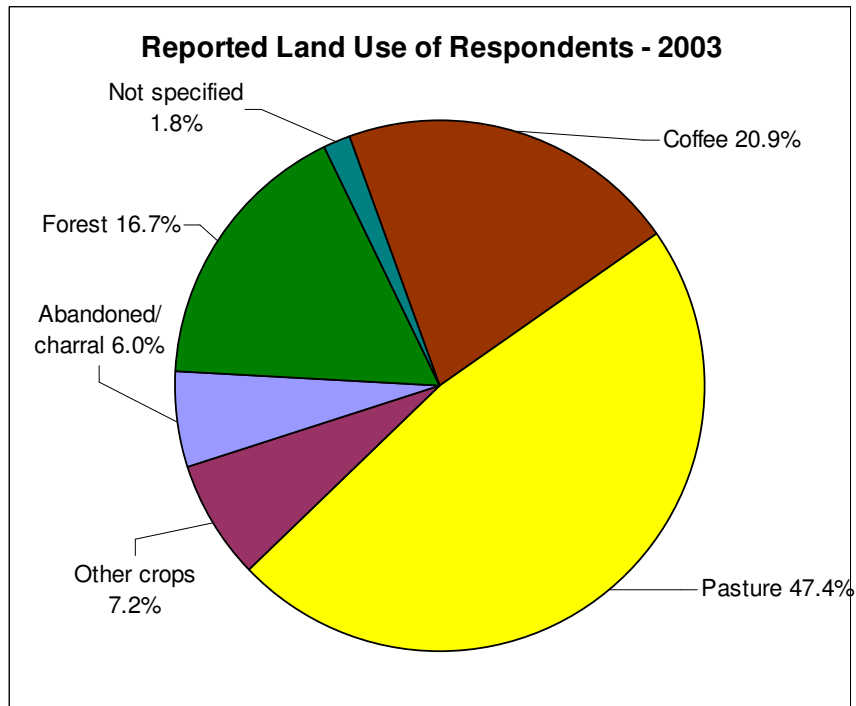


Figure 2.4.2. Land use of sample in 2003, at the time that interviews were conducted. Total land area represented is 457 hectares (reduction from 1997 is due to farmers selling land).

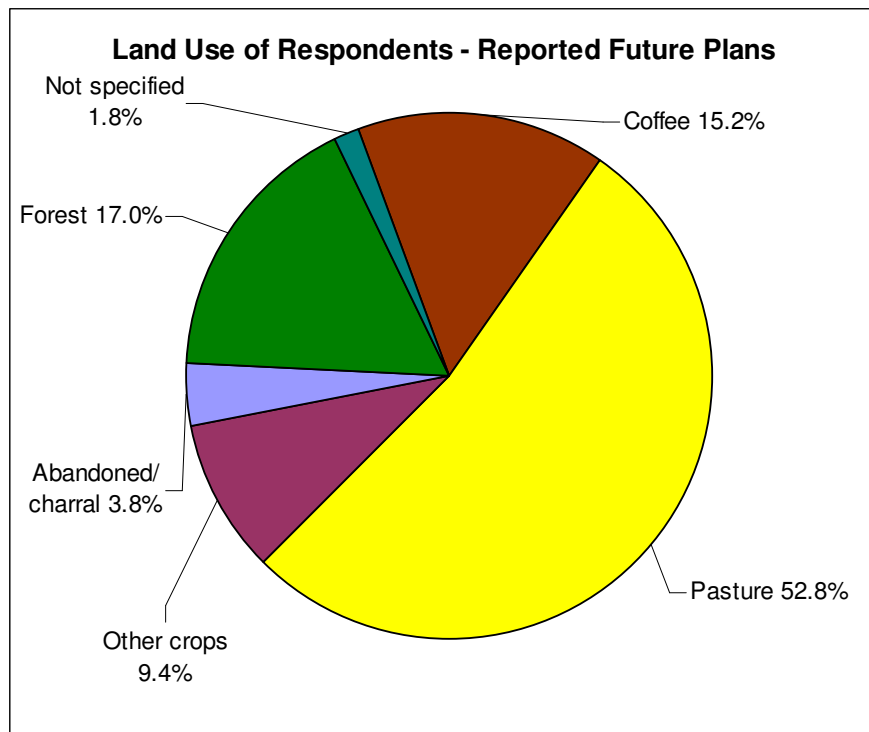


Figure 2.4.3. Planned future land use of sample based on respondents' descriptions of their plans for their land, not taking into account respondents' plans to leave the region. Total land area represented is 456 hectares (reduction from 2003 is due to farmers planning to sell land).

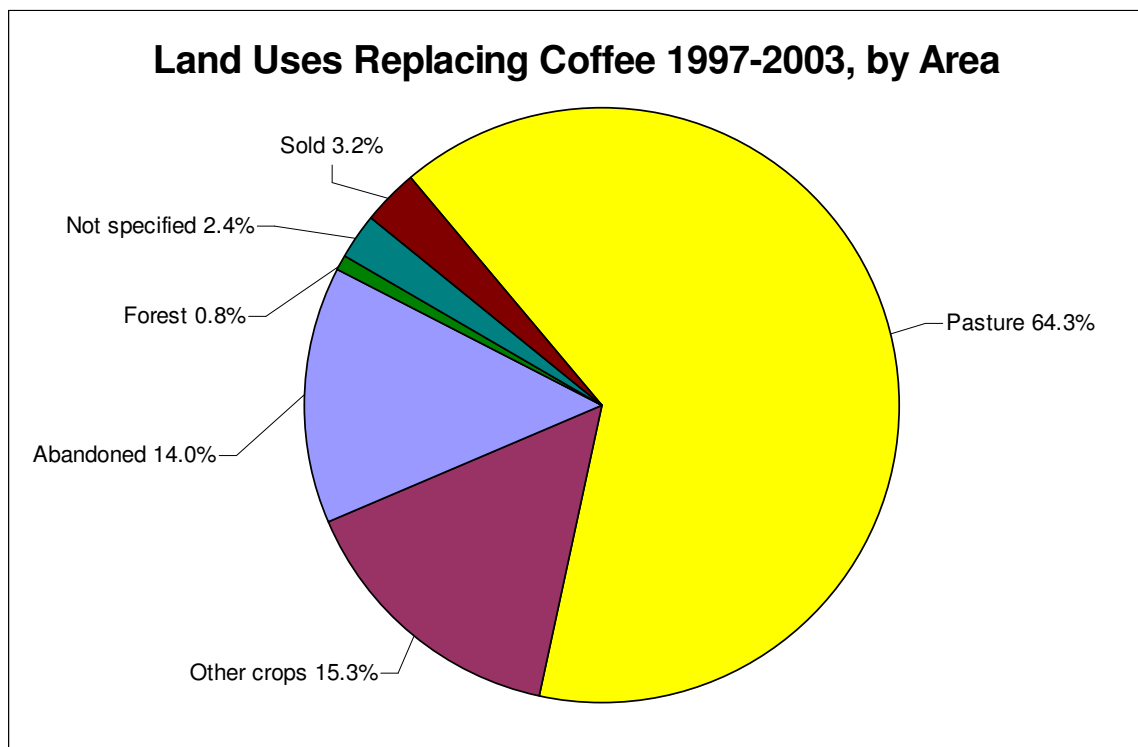


Figure 2.4.4. Land use, by area, replacing coffee that was removed.

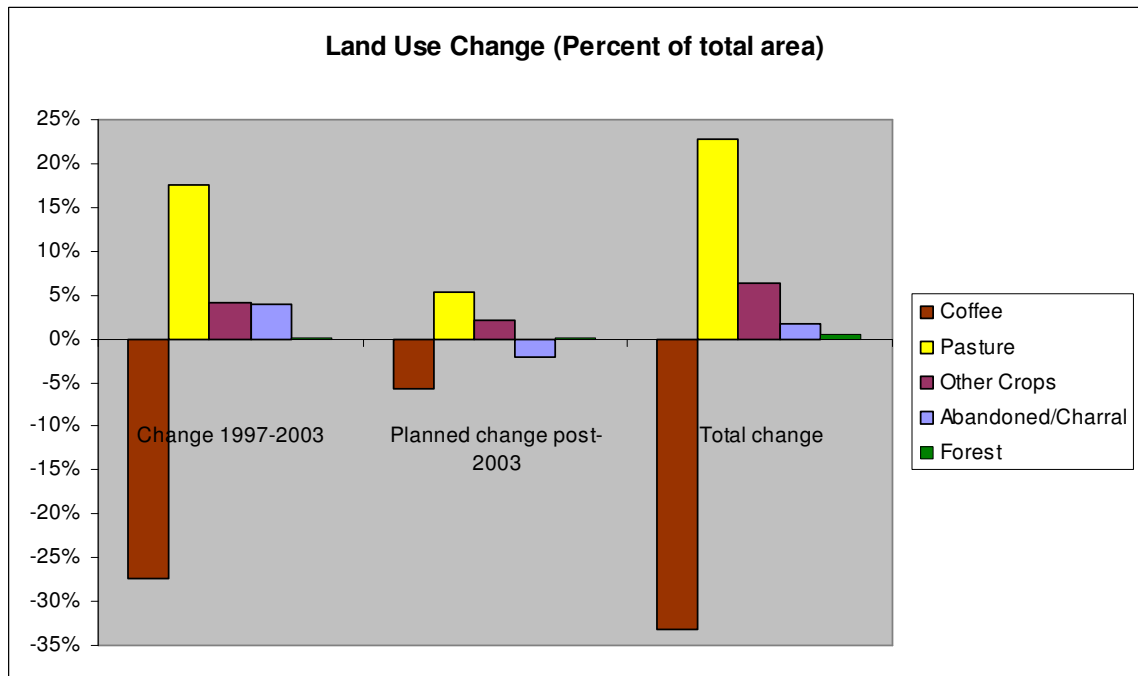


Figure 2.4.5. Land use change as a percent of the total original area represented by respondents' farms.

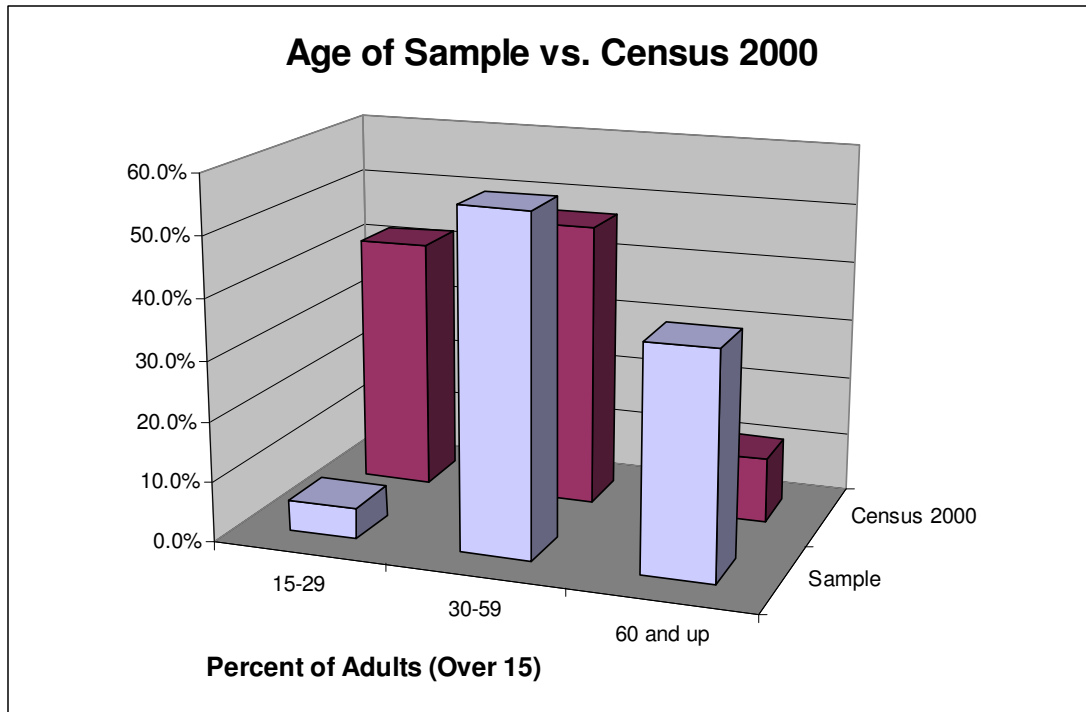


Figure 2.4.6. Age of survey respondents compared to ages of adults in Coto Brus as a whole. Census 2000 data from (INEC 2001).

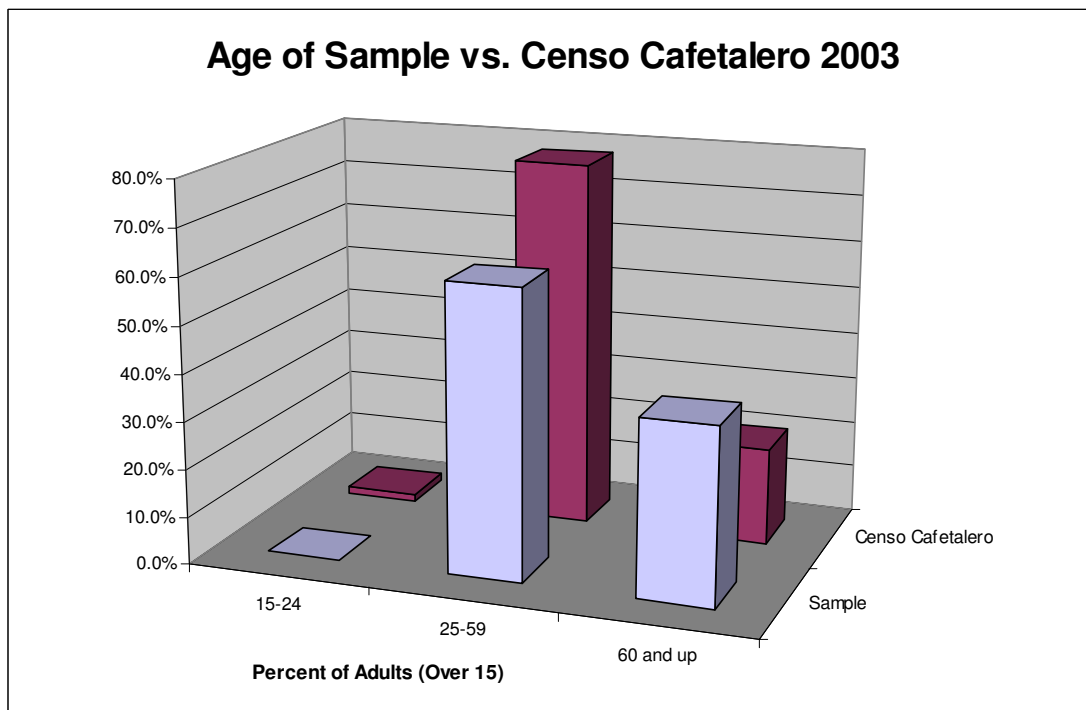


Figure 2.4.7. Age of survey respondents compared to ages of respondents in the 2003 *Censo Cafetalero* (INEC 2004).

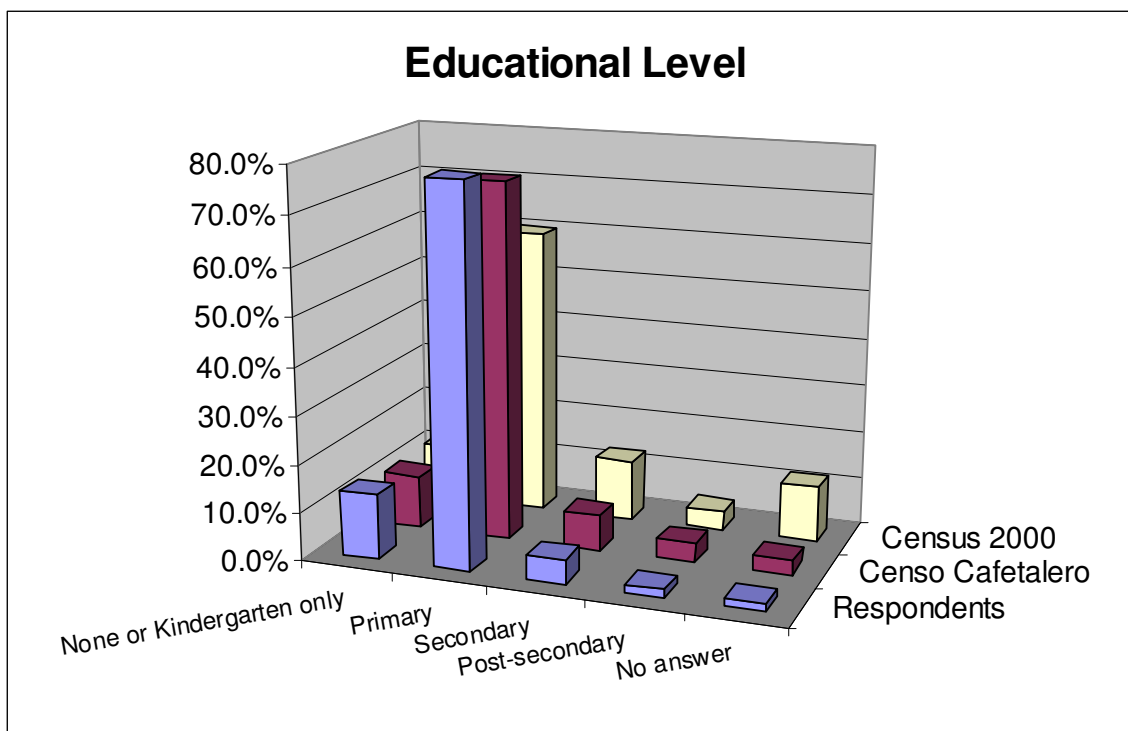


Figure 2.4.8. Educational level of survey respondents compared to results of the *Censo Cafetalero* for Coto Brus and Turrialba, and the 2000 Census for Agua Buena.

H2: Effects of conversion on bird life

Hypothesis: Coffee farms that have been converted to cattle pasture will show a lower bird diversity and richness than coffee farms that have not been converted.

Introduction

The previous section found support for the hypothesis that, presented with the low prices of the past decade, farmers in Agua Buena were converting their coffee to other land uses, and that the predominant new land use by area was cattle pasture. Given the apparent scale of this conversion, and the fact that the agricultural matrix - with its various components such as pasture, coffee and vegetable crops - is largely the only habitat remaining in the study area, it is important to examine whether the conversion from coffee to pasture will result in a loss of habitat for wildlife.

As many as 380 species of birds, or 32-45% of Costa Rica's 840 species (Stiles & Skutch 1989), are believed to have once inhabited the southern half of Coto Brus (Hughes et al. 2002), which includes the district of Agua Buena. The Las Cruces Biological Station bird checklist (Stiles et al. 1996) is considered a good baseline for the species that once occurred in the area (Daily et al. 2001). Dramatic forest fragmentation and loss due to clearing for agriculture has occurred in this portion of the *cantón* over the past 50 years, with the largest remaining fragment represented by the 227-hectare forest at the Las Cruces Biological Station.

Surveys conducted in 1995 found 272 species living in both forested and open habitats in the area, with 123 species observed at least part of the time in open habitats, while over 50% of species, or 149, were observed only in fragments of primary forest (Daily et al. 2001). In 1998, Hughes et al. (2002) observed 144 bird species utilizing agricultural habitat in Coto Brus. Another set of surveys, carried out by Lindell et al. (2004) from 1998-2000, detected 271 species in both forested and agricultural habitats (including coffee), of which 81 species, or 29.9%, were only found in primary or mature secondary forest. Characteristics of the birds utilizing the Coto Brus agricultural landscape are discussed in detail in Lindell et al. (2004), and both Daily et al. (2001) and

Lindell et al. (2004) provide detailed information on characteristics of birds utilizing agricultural and forest habitats in the area.

Methods

Study area and site selection

The study area is located between 8°40' N and 8°50' N, and between 82°55' W and 83°00' W (IGNCR 1975). The area is classified as a premontane rainforest life zone (Holdridge 1971; cited in Rosemeyer et al. 2000), where precipitation averages 3600-4000mm per year. The wet season is considered to be April through November, when it rains almost daily, usually in the afternoons. During the dry season, December through March, it rains approximately once every two weeks (Rosemeyer et al. 2000).

Eight sites were selected for surveys: four working coffee farms, and four pastures that had been converted from coffee within the past six years but still contained many of the overstory trees. All sites were between 1000 and 1200m in elevation and were between 1.3 and 2.5 hectares in size, as estimated by GPS data (see below). Figure 2.4.11 shows a map of the study area, with survey sites marked.

Sites of similar habitat were no less than 500m from each other, and sites of differing habitat were no less than 250m of each other, with the exception of pasture sites 3 and 4, which were only 200 m from each other, separated by a 100m strip of gallery forest, a 75 m strip of pasture, and a dirt road. Pasture and coffee sites were selected to represent management styles typical for the area based upon personal observations. Site selection was influenced by transportation constraints and the availability of patches of homogenous habitat large enough to contain a survey site. Information regarding land management practices was obtained through questioning landowners, neighbors and farm workers. Detailed site descriptions are provided in Appendix B.

Pasture sites (Figure 2.4.9) had originally been coffee farms with mixed shade cover of *Erythrina spp.* ("poró"), *Musa spp.* (banana/plantain) and/or *Citrus spp.* (primarily oranges). The sites had been cleared of all coffee trees and some shade trees within the past six years. None of the sites were currently under treatment with any

agrochemicals, with the exception of Site 4, which was treated with the herbicide mixture Tordon (2,4-D picloram) during the survey period.

Coffee sites (Figure 2.4.10) were coffee farms in active production. Heights and distances for vegetation cover are estimates based on visual observation. All sites had a mixed shade cover of *Erythrina spp.*, *Musa spp.* and/or *Citrus spp.*, at a distance of approximately one tree per 7-10 meters, now a typical management system for the Agua Buena region. All shade trees on the sites were 5-10 m tall and in good condition with wide, leafy crowns, unless otherwise specified. Coffee bushes were between 1 and 2 m high, at a density of 3,000-4,000 bushes per hectare. All sites had approximately a 5 cm layer of organic mulch covering the ground, and a dense layer of herbaceous weeds less than 1 m high. No chemical fertilizers, fungicides or insecticides had been applied to any of the farms during the preceding year, but one site was treated with Roundup (glyphosate) during the survey period.

GPS data

Data points for plot boundaries were taken in July 2003. ESRI ArcMap 9.0 was used to generate polygon coverage using these data points, then to obtain the area for each plot and to determine the minimum distances between sites. The polygons were projected onto an aerial photo of the study area (IGNCR 1998) provided by Dr. Karen Holl, Department of Environmental Studies, University of California, Santa Cruz, to create a visual map of the survey sites (Figure 2.4.11).

Bird survey method

The survey method used to compare the bird fauna of the sites was a modified version of an area search bird census protocol provided by John Alexander of the Klamath Bird Observatory (Geupel et al. 2003, J. Alexander pers. comm. 2003). This method was chosen because it does not require the observer to be able to immediately identify all the birds of an area by sight and call, but produces relatively complete, statistically comparable samples (Dieni & Jones 2002). It appears that all of the published work using this method has, to date, been conducted in temperate regions. A

further discussion of the relative effectiveness of the area-search protocol compared to other methods is available in Appendix B.

Each site was divided into two survey plots of approximately equal size, based upon natural or constructed boundaries such as paths, fences, or hills, for a total of 16 plots. Pilot surveys determined that an appropriate period of time for these searches was 15 minutes, allowing complete coverage of both coffee and pasture plots, with minimal backtracking. The observer started at one end of the plot and moved slowly in a zigzag or C-shape (depending on the shape of the plot and visibility), in such a way as to survey all parts of the plot, finishing the 15 minute period at the other end of the plot. If the observer neared the other side of a plot before the survey time was up, they would return to an area near the center of the plot, with high visibility, and remain there watching for new birds until the time was up. Notes were taken using a hand-held tape recorder, and transcribed at the end of each day.

All birds seen, and birds heard that could be reliably identified and which the observer was sure were inside the plot, were counted. Care was taken not to double-count individuals. With the exception of hummingbirds, only birds that were observed perching or foraging on vegetation in the plot, or on the ground, were counted (i.e. birds that flew overhead were not included). Hummingbirds were counted when they were observed foraging on vegetation within the plot. Birds located in living fence trees bordering the plots were not counted unless they were also observed inside the plot. The habitat where a bird was situated was recorded if the bird was seen, or if a bird identified by voice could be reliably located. Breeding activity was noted.

Surveys were carried out during the wet season, from August 18 through September 14. The plots were each sampled six times over this one-month period, between the hours of 5:15 a.m. and 9 a.m. To avoid any biases based on the time in the morning that the sites were sampled, searches were scheduled so that each plot was searched once each between 5:15 and 5:59 a.m., 6 and 6:59 a.m., 7 and 7:59 a.m., and 8 and 8:59 a.m., and once each between 5:15 and 6:59 a.m. and 7 and 8:59 a.m. The time of sampling refers to the time at which the survey was begun. Figure B.1 in Appendix B

gives a visual explanation of the site and survey design, and Table B.1 gives the schedule on which the surveys were conducted.

It is conventional to express the start times of these types of surveys as time from sunrise (Steven G. Herman, Evergreen State College, pers. comm. 2005). The proximity of the survey area to the equator meant that, between the start and end dates of the surveys, the sunrise time only ranged from 5:22 a.m. to 5:24 a.m. (U.S. Naval Observatory 2005). Thus, the fact that the rotation of survey times was not based on sunrise time most likely did not have a significant effect on the results.

Most of the counts took place outside the migratory season, but a few migrants began to arrive during the last few days of counting. Because of this slight overlap, counting migrants would inflate species diversity for the last few surveys done. Therefore, while migrants were noted during the surveys, they are not included in the data analysis.

Data analysis

Information on family for each species were obtained from Stiles and Skutch (1989) and verified with the American Ornithologists' Union checklist (American Ornithologists Union 2005). Habitat associations were taken from Hughes et. al. (2002). When a species was not listed in this source, habitat association was assessed using information from Stiles and Skutch. Birds were categorized as being primarily associated with forest or open areas, or as being normally present in both, and relative percentages of both individuals and species associated with each habitat type were compared for pasture and coffee. The feeding guild for each species was determined using information from Stiles and Skutch (1989).

Survey data were analyzed using EstimateS software (Colwell 2005b). EstimateS uses field data to compute randomized species accumulation curves, eight statistical estimators of species richness, and three diversity indexes. These statistics were computed for each individual plot and for each site (pooling the samples from the two plots that made up each site, for a total of 12 samples per site). According to Engstrom

and James (1981; cited in Gotelli & Colwell 2001), a set of replicated samples can be pooled and treated as a single data set. Richness estimators and diversity indexes were therefore also calculated with all surveys pooled for each habitat type (48 surveys per habitat type).

Pielou (1975 pp. 17-18) discussed the idea of hierarchical diversity, which examines the diversity of a community at taxonomic levels above that of species. Later work expanding on this concept is described in Magurran (2004 pp. 121-123). Communities with similar numbers of species are considered more diverse if those species belong to a greater number of higher taxonomic groups. In other words, a community with two species is more diverse if those two species belong to separate genera than if they are congeneric, more diverse still if the two species belong to separate families, and so on. To examine this aspect of diversity, richness and diversity indexes were computed at the family as well as the species level.

Statistical analyses were performed using SPSS 10.0.5 and Microsoft Excel 2003. See Appendix B for a discussion of non-sampling error sources and their importance to the results.

Richness refers to the actual number of types of organisms present at a site, at a pre-determined taxonomic level (such as species, genus or family), and is the simplest and most intuitive way of quantifying biodiversity. Observed species richness was compared using a 1-way, 2-group ANOVA, with surveys for plots A and B pooled for each site, and each site treated as a single subject, resulting in four subjects per group.

In general, it is not possible to sample all the species that may use a given site, or be certain that all species have been sampled (Chao 2004). Instead, it is necessary to use statistical estimators of true species richness. In addition to observed species richness, I selected six richness estimators, based on those used in Hughes et al. (2002):

1. Incidence-Based Coverage Estimator (ICE) of species richness (Chazdon et al. 1998; Lee & Chao 1994; cited in Colwell 2001)
2. Chao 2 richness estimator (Chao2) (Chao 1987; cited in Colwell 2001)

3. First-order Jackknife richness estimator (Jack1) (Burnham & Overton 1978; 1979; Smith & Belle 1984; Heltshe & Forrester 1983; all cited in Colwell 2001)
4. Second-order Jackknife richness estimator (Jack2) (Palmer 1991; Smith & Belle 1984; all cited in Colwell 2001)
5. Bootstrap richness estimator (Bootstrap) (Smith & Belle 1984; cited in Colwell 2001)
6. Michaelis-Menten richness estimator (MMMean) (Raaijmakers 1987; cited in Colwell 2001)

While richness is a simple count of the total number of taxonomic units at a site, diversity takes into account both the richness of a site and the relative abundance of the different taxonomic units. A site dominated by one or a few types of organism is considered to be less diverse than a site with equal numbers of different types of organisms, even if both sites have the same richness.

EstimateS computes three diversity indices based upon richness and relative abundance:

1. Fisher's Alpha diversity index (Hayek & Buzas 1996; cited in Colwell 2001; Magurran 1988)
2. Shannon diversity index (Hayek & Buzas 1996; cited in Colwell 2001; Magurran 1988)
3. Simpson reciprocal diversity index (Hayek & Buzas 1996; cited in Colwell 2001; Magurran 1988)

The three diversity estimators were compared using a 1-way, 2-group ANOVA, with surveys for plots A and B pooled for each site, and each site treated as a single subject. According to Sokal and Rohlf (1995; cited in Magurran 2004 p. 151), ANOVA is an acceptable method for comparing diversity indexes when multiple samples have been taken.

Results

A total of 1,896 registrations of 62 species from 25 families were made during the surveys, with 1,078 registrations of 45 species from 17 families in pasture, and 764 registrations of 48 species from 22 families in coffee. Thirty-two species and fifteen families were shared by both habitat types, with fourteen species and three families detected only in pasture, and sixteen species and seven families detected only in coffee. Table 2.4.5 lists all species and families observed, total counts of each species observed in each habitat type, and habitat association and feeding guild of each species.

In pasture, fourteen species and two families were represented by only one individual. In coffee, this was the case for twelve species and three families. Rare species, defined for this study as species represented by two or fewer individuals across all samples, accounted for 31.3% of coffee species and 33.3% of pasture species. As many as five near-threatened or vulnerable resident species may reside, or have resided at one time, in the study area (IUCN 2004; Stiles & Skutch 1989). None of these species were detected during the surveys. Furthermore, none of the four species of understory insectivores identified by Şekercioğlu et al (2002) as particularly sensitive to forest fragmentation in the study region were detected.

Despite the relatively equal numbers of rare species in coffee and pasture, pasture was markedly dominated by birds of a few species from the family Emberizidae (sparrows and finches), whose members made up 64% of all registrations, with all other families having 7% or fewer registrations each. There did not appear to be any one dominant family in coffee. The most abundant family in coffee was the Thraupidae, with 22% of registrations, followed by the Troglodytidae at 16%, and the Parulidae, Trochilidae, and Tyrannidae, at 9-10% each. These observations indicate higher diversity, defined as evenness of species composition, in coffee at the family level. The percent of registrations for species belonging to each family detected is shown in Figure 2.4.12. These qualitative observations were supported by the quantitative analysis below.

Total observed richness was higher in coffee for both species and families. Figure 2.4.13 and Figure 2.4.14 show richness estimates for bird species and families,

respectively, derived when all samples are pooled for each habitat type (e.g., 48 samples per habitat type), as well as the observed richness of species and families at the pooled sites. No consistent pattern emerges for richness at the level of species. The six richness estimators differed in which habitat type they predicted would have a greater total richness. The ICE, first-order Jackknife, Bootstrap and Michelis-Menten estimates predict higher species richness in coffee, while the Chao2 estimate and the second-order Jackknife estimate predict higher species richness in pasture.

Observed species richness did not differ between habitats (one-way ANOVA, $F=4.573$, $df=7$, $p=0.76$). These results, combined with the lack of consistency among the other estimators, means that it cannot be concluded that there is a significant difference between the species richness of the coffee and pasture sites. At the family level, however, coffee sites consistently showed higher predicted richness for all estimators. Observed family richness between habitat types was significantly different (one-way ANOVA, $F= 6.750$, $df=7$, $p=0.041$).

Diversity was higher in coffee for both species and families, as measured by Fisher's Alpha, Shannon and Simpson Diversity indexes (Figure 2.4.15 and Figure 2.4.16). For species, the Shannon and Simpson indexes were significantly higher ($p<0.05$) for coffee than for pasture, but the difference in the Alpha index was not significant. For families, all three indexes were significant at the $p<0.05$ level (see Table 2.4.6 and Table 2.4.7 for summaries of F-values and significance levels for these three tests).

Not surprisingly, pasture showed a higher percentage, in terms of both numbers of registrations and number of species, of birds associated with open habitats, while coffee showed a higher proportion of birds associated with forested habitats and with both forested and open habitats (Figure 2.4.17 and Figure 2.4.18). Number of registrations was significantly different for habitat association between pasture and coffee ($\chi^2=366.58$, $df=2$, $p=0.000$).

This same pattern held for the habitat associations of species (as opposed to numbers of registrations). A χ^2 test could not be performed on the numbers of species by habitat association, because the expected values for forest species were below 5 for both pasture and coffee. To enable a Fisher's Exact Test, which requires a 2x2 table, the number of open-country species found in coffee and pasture was compared to the number of forest species in each, with generalist (species associated with both habitat types) excluded. This comparison revealed no significant differences between the habitat types ($N=57$, $p=0.408$). Of the fourteen species found only in pasture, one (7%) was associated with forest, ten (71%) with open areas, and three (21%) with both. Of the sixteen species that were found only in coffee, three (19%) were associated with forest, four (25%) with open areas, and nine (56%) with both.

Percent of registrations from each habitat type by guild is shown in Figure 2.4.19, and Figure 2.4.20 shows percent of species by guild. Pasture shows a striking dominance by granivores, while coffee has twice the proportion of insectivores and frugivores, and five times the proportion of nectarivores, as pasture (χ^2 , $df=5$, $p=0.001$). Species composition by guild appears to be fairly similar between habitat types, although small expected values preclude testing with a χ^2 test.

Of those species that were detected only in pasture, one (7%) was a frugivore, one (7%) was a granivore, ten (71%) were insectivores and two (14%) were omnivores. Of those species that were only found in coffee, one (6%) was a carnivore, five (31%) were frugivores, one (6%) was a granivore, seven (44%) were insectivores, and two (13%) were omnivores. Four of the seven species of insectivores found only in coffee, none of the ten found only in pasture, and one species found in both habitats, could be classified as understory insectivores.

Discussion and Conclusions

The lower diversity in converted coffee (pasture), the lower taxonomic richness (family richness) and greater proportion of open-habitat birds in pasture, the higher proportion of insectivores in coffee, and the presence in coffee of understory insectivores

not found in pasture support the argument that conversion of coffee farms to pasture will have a negative impact on biodiversity and habitat availability in the region. Based on these results, H2, which states that “coffee farms that have been converted to cattle pasture will show a lower bird diversity and richness than coffee farms that had not been converted,” is partially supported.

Species richness did not differ significantly between the two habitat types. Initial power analysis prior to the surveys indicated that four sites per habitat type was an adequate sample to test for species richness, but this power analysis relied on an estimate for the within-group variation that was too low, and an estimate for the difference between means that was too high. A *post-hoc* power analysis for the ANOVA of observed species richness reveals that the probability of detecting a real difference between means at the 0.05 significance level is less than 50% in this case. To have an approximately 80% chance of detecting a true difference in observed species richness between the two treatment types, a sample size of 8 sites per group would be required (Dunlap 1981).

A number of characteristics of the bird communities in the study sites are of interest from a conservation standpoint. A significantly higher proportion of registrations in coffee were forest-dependent species, while pasture was dominated by open-habitat species. Additionally, coffee had twice the proportion of registrations that were insectivores, four species of understory insectivores were detected in coffee and not pasture, and only one species of understory insectivore was detected in pasture. This species was also detected in coffee, and no species of understory insectivore was found only in pasture. Insectivores, particularly understory insectivores, are the guild of birds shown to be most sensitive to forest fragmentation in the study region (Sekercioglu et al. 2002) as well as other parts of the Neotropics (discussed further in Chapter 1.2).

Many of the study sites were adjacent to forest patches. During the surveys, many birds, particularly those that were only detected once or twice, were observed flying from forest patches briefly into the survey plots, then returning to the forest. Thus, it is likely

that many of the birds relied upon these patches as their primary habitat, visiting the agricultural matrix to forage or to move between patches.

These observations, combined with the difference in guild composition and habitat association discussed above, indicate that a changeover from coffee to pasture is likely to reduce important matrix habitat for forest-dependent species, and possibly reduce the mobility of birds between forest patches in this highly fragmented landscape. Other authors, discussed in Chapter 1.2, have shown that shade coffee can help provide connectivity for forest-dependent animals. The results of this study indicate that this could also be true of the relatively unshaded systems that predominate in Agua Buena.

This study, however, does not provide information on a number of other variables. For example, as described in the previous section, most coffee farmers in the area had reduced or eliminated their pesticide use due to low coffee prices, but in times of higher prices, coffee is typically a high-input crop. During interviews, some farmers mentioned finding dead birds in their fields after applications of the nematicide terbufos,^{*} which all respondents but one had subsequently stopped applying – some due to an inability to continue to pay the high price of the chemical, others due to its perceived toxicity. Thus, the impacts on bird populations from lower pesticide use could be significant.

Additionally, these surveys only looked at one alternative to coffee. Other land uses were not examined. For example, some farmers reported abandoning their land rather than converting it to an alternative use. This land abandonment, leading to regeneration of secondary forest, is likely to have a positive environmental effect. Alternatively, some farmers were changing to vegetable crops such as tomatoes and green peppers. These crops are reported by farmers to be more chemically intensive than coffee, and the soil where they are grown is typically kept bare, potentially leading to higher erosion than in coffee. Thus, conversion of coffee to these types of vegetable crops can be expected to have negative environmental effects.

^{*} S-tert-butylthiomethyl O,O-diethyl phosphorodithioate

While it is, therefore, not possible from these data to construct a complete picture of how the varied choices made by farmers in the Agua Buena region in response to low coffee prices are affecting biological diversity in the area, this research does illuminate an important component of land-use change. Interviews with farmers showed that pasture was by far the most popular alternative to coffee. Given the scale of conversion to pasture identified by the interviews, and the lower family-level taxonomic diversity observed in converted farms, the apparent reduction of habitat resulting from conversion should be cause for concern.

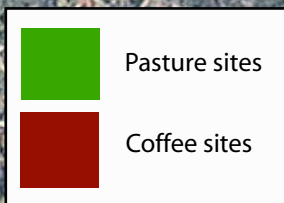
Figures



Figure 2.4.9. Example of coffee site (site shown is Coffee 3).



Figure 2.4.10. Example of pasture site (site shown is Pasture 2).



Agua Buena

Beneficio



P2



C1



C2



P3



C3



P4



C4



P1

Previous page: **Figure 2.4.11.** Map of survey sites.

Family	Species name	Common name	Feeding guild	Habitat Association	Pasture	Coffee
Tinamidae ^c	<i>Crypturellus soui</i> ^c	Little Tinamou	O	F	0	1
Cracidae ^c	<i>Ortalis cinereiceps</i> ^c	Gray-headed Chachalaca	F	B	0	1
Ardeidae ^p	<i>Bubulcus ibis</i> ^p	Cattle Egret	I	O	1	0
Cathartidae ^c	<i>Coragyps atratus</i> ^c	Black Vulture	O	B	0	3
Accipitridae	<i>Buteo magnirostris</i>	Roadside Hawk	C	O	1	1
Falconidae ^c	<i>Milvago chimachima</i> ^c	Yellow-headed Caracara	C	O	0	1
Columbidae	<i>Columbina talpacoti</i>	Ruddy Ground-dove	F	O	72	12
Columbidae	<i>Claravis pretiosa</i> ^p	Blue Ground-dove	G	O	3	0
Columbidae	<i>Leptotila verreauxi</i>	White-Tipped dove	G	B	1	24
Psittacidae ^c	<i>Aratinga finschi</i> ^c	Crimson-fronted Parakeet	F	B	0	10
Cuculidae ^p	<i>Piaya cayana</i> ^p	Squirrel Cuckoo	I	B	1	0
Cuculidae ^p	<i>Crotophaga ani</i> ^p	Smooth-billed Ani	I	O	9	0
Caprimulgidae	<i>Nyctidromus albicollis</i> ^c	Common Pauraque	I	O	0	2
Trochilidae	<i>Phaethornis guy</i>	Green Hermit	N	F	7	19
Trochilidae	<i>Phaeochroa cuvierii</i>	Scaly-breasted Hummingbird	N	B	1	2
Trochilidae	<i>Amazilia tzacatl</i>	Rufous-tailed Hummingbird	N	B	17	54
Trochilidae	<i>Helimaster longirostris</i>	Long-billed Starthroat	N	O	1	1
Picidae	<i>Picumnus olivaceus</i> [*]	Olivaceous Piculet	I	B	1	1
Picidae	<i>Melanerpes rubricapillus</i>	Red-crowned Woodpecker	I	B	10	8
Picidae	<i>Dryocopus lineatus</i> ^p	Lineated Woodpecker	I	B	1	0

Table 2.4.5. Species seen in all surveys for both habitat types, number of individuals of each species seen in each habitat type, with family, habitat association and feeding guild. For feeding guild, O=omnivore, I=insectivore, C=carnivore, G=granivore, F=frugivore. For habitat associations, O=open, F=forest, and B=both. Families and species marked with ^p were found only in pasture, and those marked with a ^c were found only in coffee. Species marked with an asterisk* are understory insectivores, based on information from Stiles and Skutch (1989)

Family	Species name	Common name	Feeding guild	Habitat Association	Pasture	Coffee
Furnariidae	<i>Synallaxis albescens</i>	Pale-breasted Spinetail	I	O	38	0
Furnariidae	<i>Synallaxis brachyura</i>	Slaty Spinetail	I	O	14	15
Dendrocolaptidae ^c	<i>Lepidocolaptes souleyetii</i> ^{c,*}	Streak-headed Woodcreeper	I	B	0	1
Tyrannidae	<i>Capsiempis flaveola</i> ^c	Yellow Tyrannulet	I	O	0	1
Tyrannidae	<i>Elaenia flavogaster</i>	Yellow-bellied Elaenia	I	O	9	5
Tyrannidae	<i>Zimmerius villosissimus</i> ^c	Paltry Tyrannulet	F	B	0	8
Tyrannidae	<i>Lophotriccus pileatus</i> ^{c,*}	Scale-crested Pygmy-tyrant	I	F	0	1
Tyrannidae	<i>Todirostrum cinereum</i>	Common Tody-flycatcher	I	O	12	44
Tyrannidae	<i>Myiophobus fasciatus</i> ^p	Bran-colored Flycatcher	I	O	6	0
Tyrannidae	<i>Myiarchus tuberculifer</i> ^p	Dusky-capped Flycatcher	I	F	1	0
Tyrannidae	<i>Megarynchus pitangua</i>	Boat-billed Flycatcher	I	B	1	5
Tyrannidae	<i>Myiozetetes similis</i> ^p	Social Flycatcher	I	O	2	0
Tyrannidae	<i>Myiodynastes luteiventris</i> ^p	Grey-capped Flycatcher	I	B	1	0
Tyrannidae	<i>Tyrannus melancholicus</i>	Tropical Kingbird	I	O	8	4
Vireonidae ^c	<i>Hylophilus decurtatus</i> ^c	Lesser Greenlet	I	F	0	2
Troglodytidae	<i>Thryothorus modestus</i>	Plain Wren	I	O	8	45
Troglodytidae	<i>Thryothorus rutilus</i> ^{c,*}	Rufous-breasted Wren	I	B	0	25
Troglodytidae	<i>Troglodytes aedon</i>	House Wren	I	O	42	52
Sylviidae	<i>Polioptila plumbea</i>	Tropical Gnatcatcher	I	B	2	22
Turdidae	<i>Catharus aurantirostris</i> ^{c,*}	Orange-billed Nightingale-thrush	I	B	0	31
Turdidae	<i>Turdus grayi</i>	Clay-colored Robin	O	B	4	24
Parulidae	<i>Basileuterus rufifrons</i> ^c	Rufous-capped Warbler	I	O	0	30
Parulidae	<i>Coereba flaveola</i>	Bananaquit	N	B	16	47

Table 2.4.5. Continued.

Family	Species name	Common name	Feeding guild	Habitat Association	Pasture	Coffee
Thraupidae	<i>Tachyphonus rufus</i> ^c	White-lined Tanager	F	B	0	6
Thraupidae	<i>Ramphocelus passerinii</i>	Scarlet-rumped Tanager	F	O	31	49
Thraupidae	<i>Thraupis episcopus</i>	Blue-gray Tanager	F	O	24	62
Thraupidae	<i>Thraupis palmarum</i> ^p	Palm Tanager	F	O	1	0
Thraupidae	<i>Tangara icterocephala</i>	Silver-throated Tanager	F	B	7	33
Thraupidae	<i>Tangara larvata</i>	Golden-hooded Tanager	F	B	8	21
Emberizidae	<i>Volatinia jacarina</i>	Blue-black Grassquit	G	O	266	4
Emberizidae	<i>Sporophila americana</i>	Variable Seedeater	G	O	117	12
Emberizidae	<i>Sporophila nigricollis</i>	Yellow-bellied Seedeater	G	O	91	2
Emberizidae	<i>Oryzoborus funereus</i> ^c	Thick-billed Seed-Finch	G	O	0	2
Emberizidae	<i>Tiaris olivaceus</i>	Yellow-faced Grassquit	G	O	106	19
Emberizidae	<i>Arremonops conirostris</i>	Black-striped Sparrow	O	O	22	12
Emberizidae	<i>Zonotrichia capensis</i>	Rufous-collared Sparrow	G	O	85	7
Cardinalidae	<i>Saltator striatipennis</i> ^p	Streaked Saltator	I	O	1	0
Cardinalidae	<i>Saltator maximus</i>	Buff-throated Saltator	O	B	10	10
Icteridae ^p	<i>Quiscalus mexicanus</i> ^p	Great-tailed Grackle	O	O	3	0
Icteridae ^p	<i>Molothrus aeneus</i> ^p	Bronzed Cowbird	O	O	8	0
Fringillidae	<i>Euphonia lanirostris</i> ^c	Thick-billed Euphonia	F	B	0	1
Fringillidae	<i>Carduelis psaltria</i>	Lesser Goldfinch	G	O	8	22

Table 2.4.5. Continued.

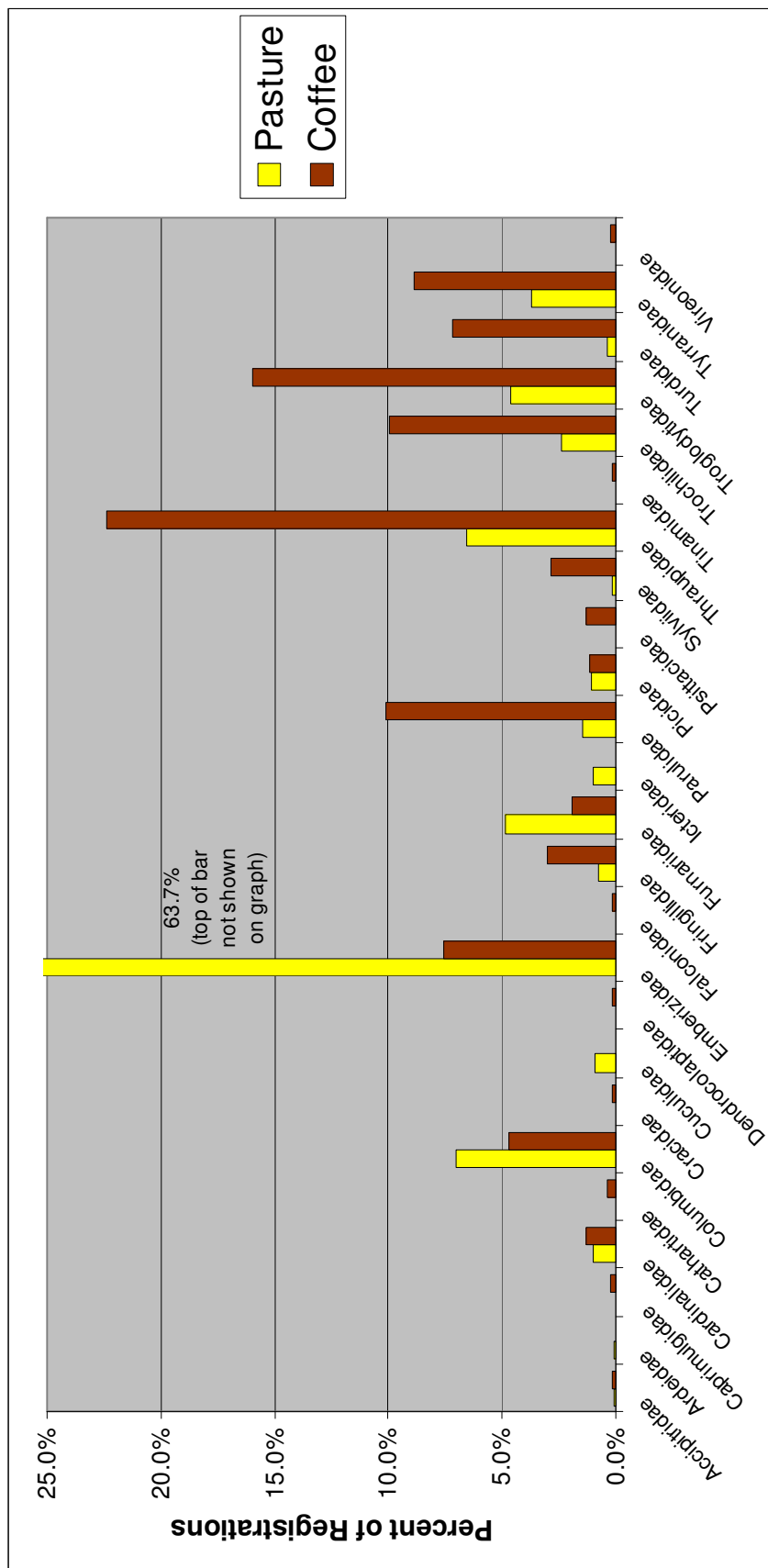


Figure 2.4.12. Percent of all registrations by family for pasture and coffee. The top of the bar for the Emberizidae for pasture is not shown, as showing it would make the smaller bars unreadable.

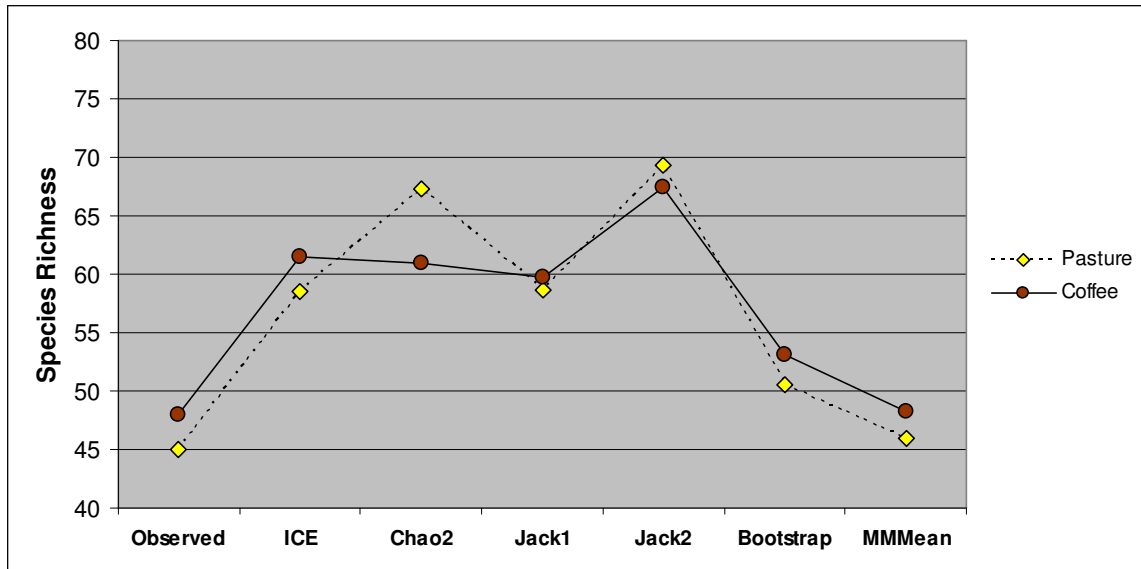


Figure 2.4.13. Species richness estimates for pooled samples. “Observed” refers to the total number of species actually observed during surveys. See text for discussion of richness estimators denoted in legend.

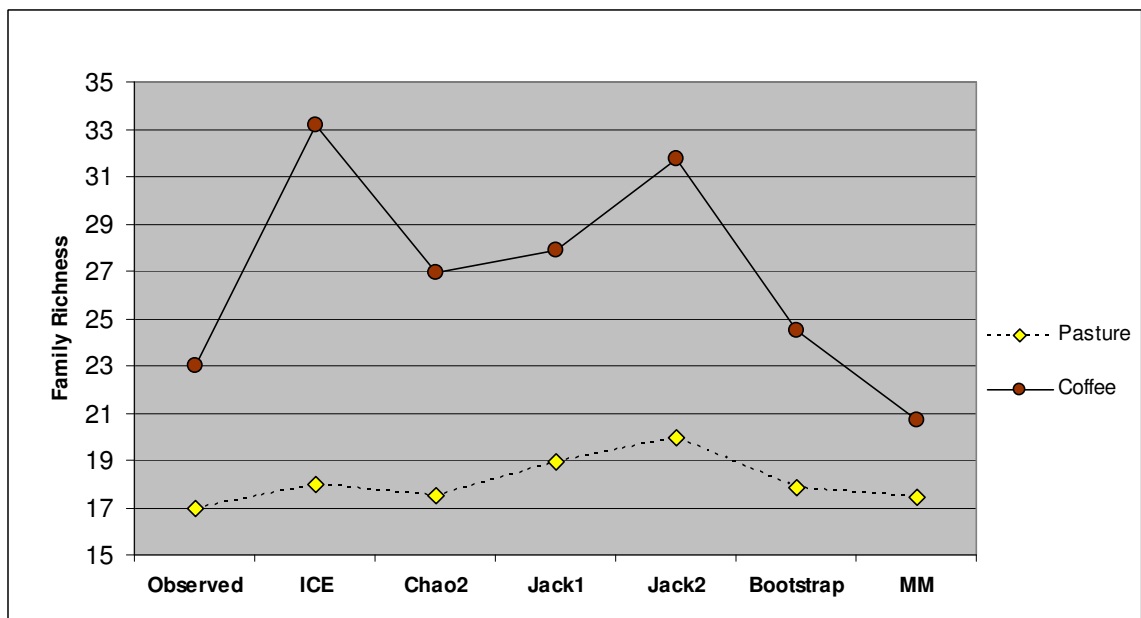


Figure 2.4.14. Family richness estimates for pooled samples. “Observed” refers to the total number of families actually observed during the surveys. See text for discussion of richness estimators denoted in legend

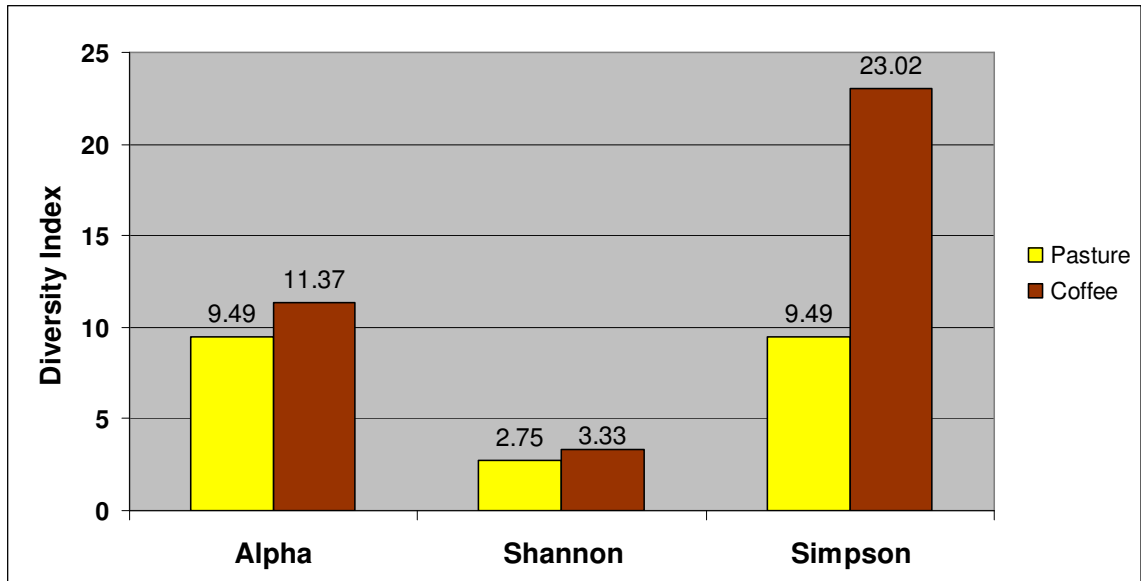


Figure 2.4.15. Species diversity indexes for samples with all sites pooled.

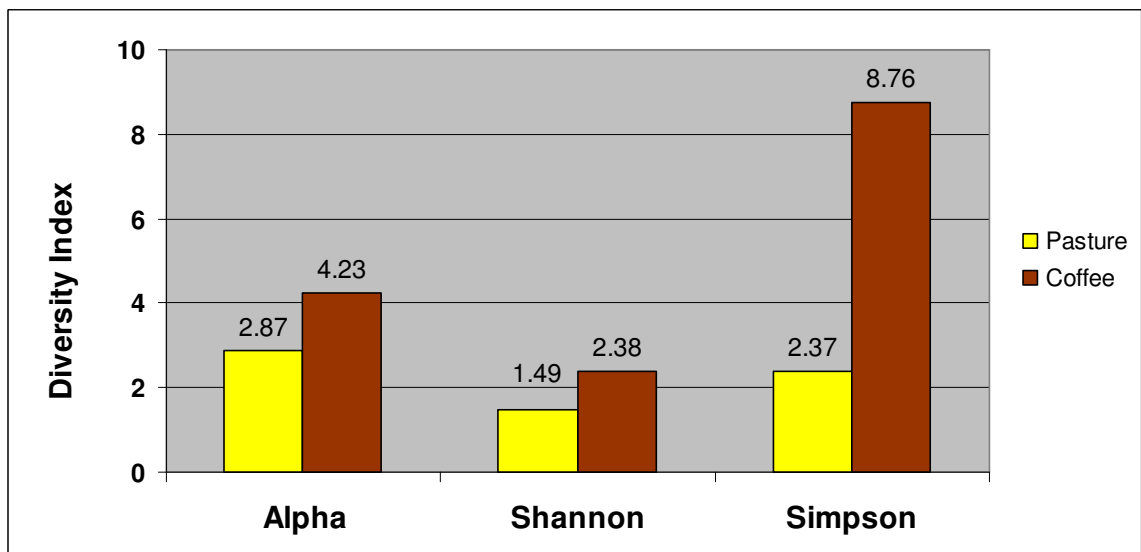


Figure 2.4.16. Family diversity indexes for samples with all sites pooled.

Index	Mean - Pasture	Mean - Coffee	df _{tot}	F	Sig.
Alpha	7.8000	10.8775	7	3.300	.119
Shannon	2.5675	3.1050	7	*14.919	.008
Simpson	9.1650	19.8150	7	*32.964	.001

Table 2.4.6. Results of ANOVA for the Alpha, Shannon and Simpson diversity indexes for species in each site. F values with an asterisk are significant at the $p < 0.05$ level.

Index	Mean - Pasture	Mean - Coffee	df _{tot}	F	Sig.
Alpha	2.7825	4.0025	7	*10.376	0.018
Shannon	1.4100	2.2800	7	*23.877	0.003
Simpson	2.7350	8.0325	7	*44.018	0.001

Table 2.4.7. Results of ANOVA for the Alpha, Shannon and Simpson diversity indexes for families in each site. F values with an asterisk are significant at the $p < 0.05$ level.

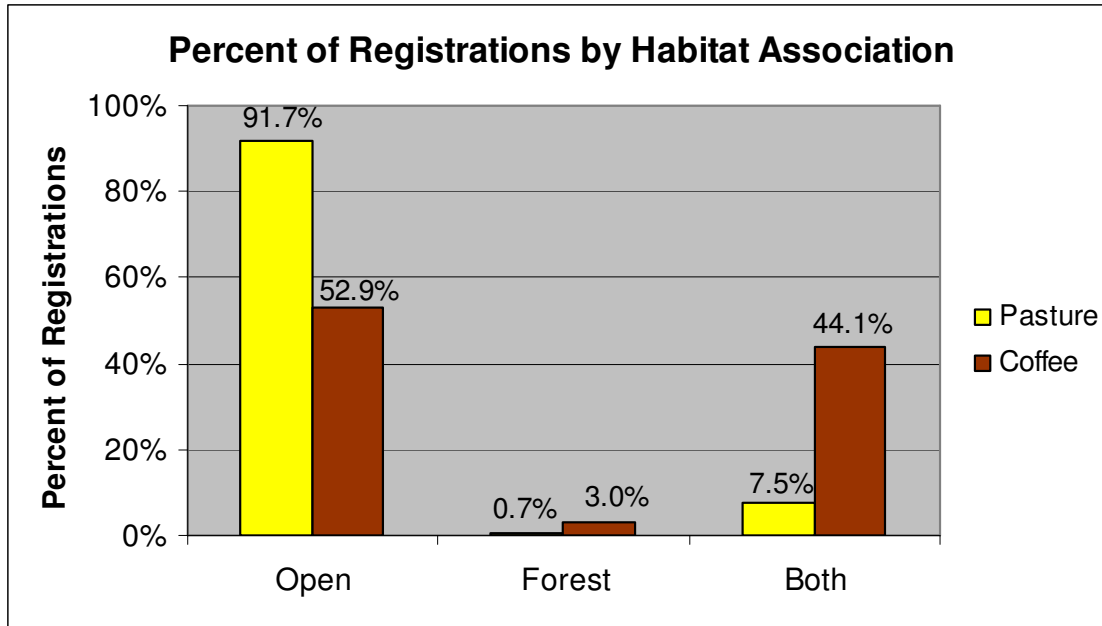


Figure 2.4.17. Relative abundance of birds recorded in survey plots that, according to Hughes et al. (2002) and Stiles and Skutch (1989), are normally associated with forested vs. open habitats.

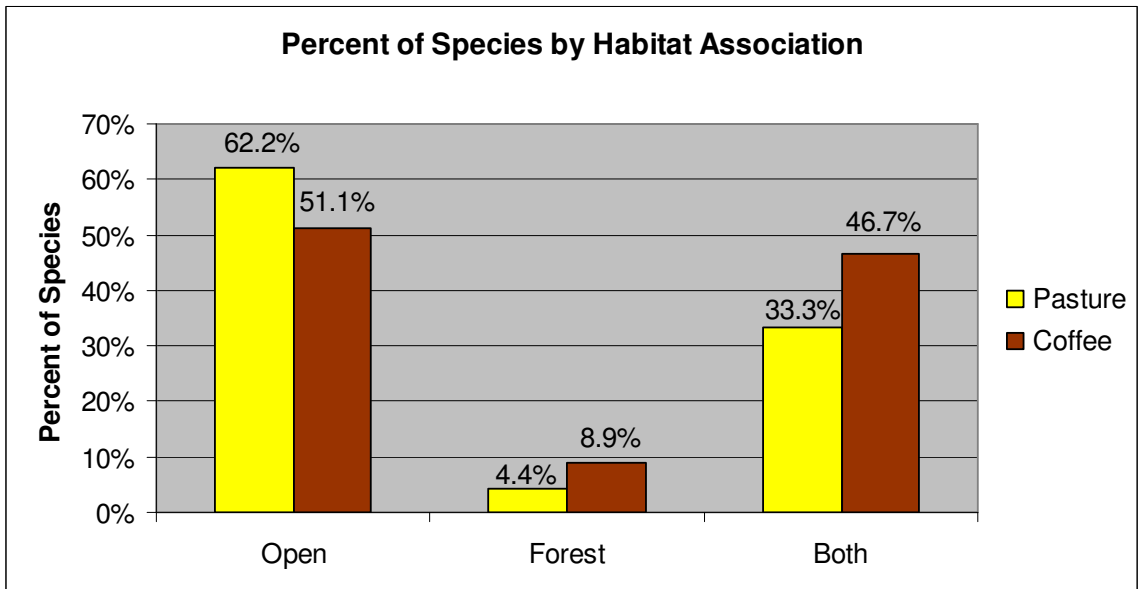


Figure 2.4.18. Percent of bird species recorded in survey plots that, according to Hughes et al. (2002) and Stiles and Skutch (1989), are associated with forested vs. open habitats.

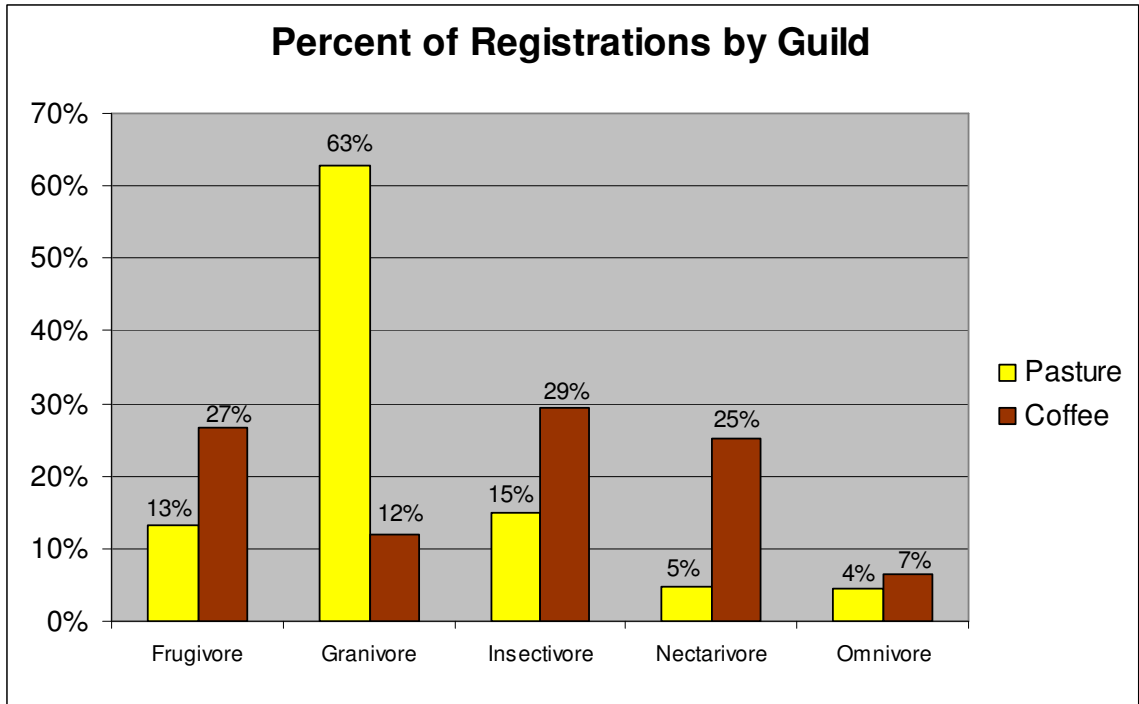


Figure 2.4.19. Percent of bird registrations in each feeding guild. Carnivores are not shown because their bars are too small to see. A total of three carnivores were observed in all survey sites.

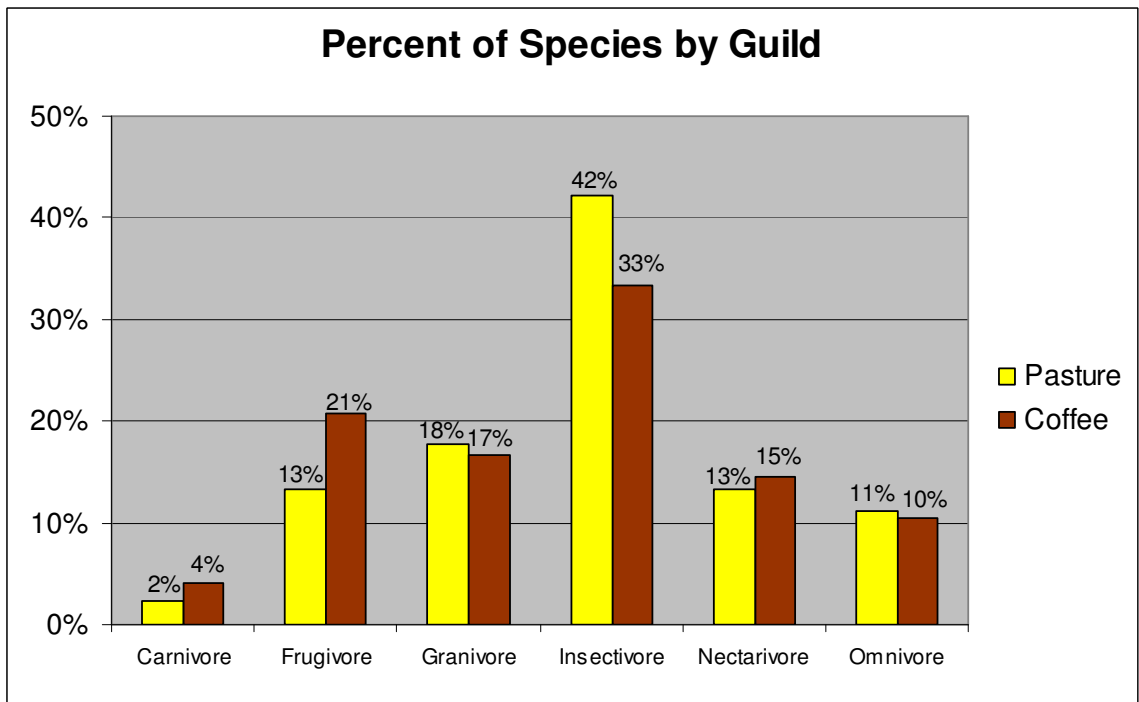


Figure 2.4.20. Percent of species in each feeding guild.

III. Conclusions and Alternatives

1. Environmental consequences

There are three main trends that reveal themselves across scales when we examine the responses of farmers to low coffee prices: reduction of chemical and labor inputs, changing to different crops, and land abandonment. No one of these factors has easily-quantifiable environmental consequences, although this thesis has partially illuminated one aspect of the last.

Land abandonment *may* lead to secondary forest regeneration on the abandoned plot, but the abandoned land can just as easily be sold cheaply for conversion to pasture or, in population-dense areas such as the Central Valley of Costa Rica, for development. Land abandonment and the reduction of labor inputs also contribute to urbanization and its accompanying environmental impacts. According to Varangis et. al. (2003 p. 18), abandonment of coffee trees or the elimination all chemical controls (when not replaced by appropriate, non-chemical technologies) can lead to the spread or worsening of pests and diseases, which could further lower profitability for neighboring farmers, or force them to further increase their own chemical applications.

The reduction of chemical inputs has clearly positive environmental effects. This strategy, however, may be a short-term one, serving as a transition to land abandonment or a changeover to another crop, as the yields typically obtained without chemicals and without an increase in labor will not provide a sufficient income for most farmers. According to Anthony Winson (1989 p. 115), a Costa Rican farmer needed 4 hectares of coffee or more at Costa Rica's high average yields and 1980's prices to provide a subsistence income for a family. With the average coffee farm size in Coto Brus being 3.9 ha (Sandoval 2002 p. 4), and the median size from the surveyed Agua Buena households at 3.0 ha, it can be anticipated that most farmers will not be able to continue living off income from coffee in the long term at post-1989 price levels. This could lead, in turn, to more land abandonment or a changeover to other, less sustainable crops, such as pasture, tomato and green pepper.

Conversion to pasture, at least in the Agua Buena region, has clear negative effects on the availability of habitat for bird communities, as demonstrated in the previous chapter. Pasture may still, however, be a preferable alternative to other more chemically intensive land uses, such as the production of tomatoes, green peppers, and other commercial vegetable crops. Given that all pasture sites in this study retained many of the shade trees originally planted over the coffee, it could be illuminating to conduct a comparison of pastures that had never been coffee, to assess whether tree cover was similar, and whether a difference in tree cover affected habitat availability. Luck and Daily (2003) found that isolated fruiting trees were important resources for avian frugivores in Coto Brus. Encouraging farmers who are changing from coffee to leave the shade trees may help to lessen the impact of conversion.

2. Alternatives and solutions

Since farmers can respond rapidly to lower prices by lowering agrochemical inputs, which will have impacts on production by the next harvest, the boom-and-bust cycles of coffee production have become shorter since the advent of the intensification era (Daviron 1994 p. 48). Thus, the extremely long duration of the current cycle of low prices is cause for concern, as it indicates that there is more at work than another iteration of the normal economic coffee cycle. Many coffee experts do not expect prices to ever fully recover to their pre-1989 levels. Nevertheless, volumes have been written about the coffee crisis, and many solutions have been proposed from the perspectives of numerous social, political and economic belief systems. Some of these are in the early stages of implementation. It remains to be seen which will be the most effective, but it seems clear that none of these solutions alone will be enough to solve the seemingly intractable problem of low coffee prices or their accompanying environmental impacts.

“Sustainable” coffees

A number of special certification programs have become popular in recent years, as consumers become more aware of the social and environmental effects of their morning coffee. These certification programs allow farmers to receive a price premium for their coffee, in exchange for meeting certain social and/or environmental standards.

Three labels dominate the certified coffee market: organic, fair trade, and shade grown. In addition, a number of non-certified coffees, such as “bird-friendly” coffee, are marketed to socially conscious consumers, and the Starbucks Coffee Company has implemented a set of procurement standards for all its coffee based on environmental and social criteria. This section will briefly discuss the two most important sectors of the sustainable coffee market: organic and fair trade.

Organic coffee is a set of mostly production-based (as opposed to socially-based) certification criteria, based on a principle of minimizing or eliminating the environmental and health effects that are frequently the result of chemically-intensive agriculture. Standards for organic certification can vary widely, depending on the certifying organization, but there are some areas of fairly universal agreement. All organic standards prohibit the use of synthetic chemicals, and require measures for the protection of soil and human health (Rice 2001).

Although many farmers appreciate the health and environmental benefits of organic coffee production, the premiums paid for organic coffee are the main motivating factor (Rice 2001). TransFairUSA pays a minimum of \$1.41 per pound for certified organic coffee (TransFairUSA 2004a), or \$0.15 above the fair trade floor price (TransFairUSA 2004b). The Costa Rican daily *La Nación* reports that Starbucks pays Costa Rican producers of organic coffee a premium of \$0.50 per pound (Anonymous 2005). Ultimately, the premium received depends upon the quality of the coffee and the marketing skills of the producing organization (Rice 2001).

Reliably estimating the size of the current organic market, or of growth trends, is difficult. Rice (2001) estimated that, in the late 1990’s, organic coffee represented approximately 3% of U.S. specialty coffee imports. Likewise, figures on the number of organic producers are difficult to locate (Rice 2001). According to Bray et al. (2002), Mexico is the world’s leading producer of certified organic coffee. In 2002, they estimated that 4% of Mexico’s coffee farmers, cultivating 2% of the country’s coffee area, currently sell to the certified organic market, with a total production of more than 6,000 Mt.

Unlike organic or shade-grown coffees, “fair trade” coffees address only the social and economic effects of coffee, by providing farmers with a guaranteed minimum price and long-term contracts. According to Oxfam International, the first fair trade coffee was from Guatemala, and was sold in Holland in 1973 (Gresser & Tickell 2002 p. 40). The first initiative to bring fair trade into the mainstream was begun in Holland in 1988, as a partnership with the private Max Havelaar Foundation and the Dutch government. The goal of the project was to expand from 0.3% to 10% the share of Holland’s coffee supply that was purchased from cooperatives, with a premium of \$0.90 per pound to be paid to the producer or used for microcredit and development projects. The country’s major coffee roasters responded with their own program to include in their blends 2-3% of coffee purchased directly from small producers, without raising prices or paying premiums to farmers (Pelupessy 1993 pp. 49-50).

In 1989, data showed that producers of Max Havelaar coffee were receiving \$0.09 more per pound, while consumers were paying \$0.50 more, with the extra profits being absorbed by the roasters, making “fair trade” a lucrative business for small roasters. After 1989, when free market prices fell 54%, the retail price of coffee in Holland fell by 23%, and by 9% for the Max Havelaar coffee. Although the roasters continued to take a large cut of the price premium, they were still earning less than they could if they sold “free market” coffee (Pelupessy 1993).

Pelupessy and Tilburg (1994 p. 253) calculated that in Costa Rica, farmers who sold coffee under the Max Havelaar program enjoyed an increase of about 13% in their total income from all sources. In El Salvador and Guatemala the increase was calculated at 14% and 10%, respectively. The price differential was clearly shielding some coffee farmers from the price collapse to some degree, but only a handful: even if all the Max Havelaar coffee sold in Holland in 1994 had been purchased from Central American countries, it would only account for 2% of that region’s production (Pelupessy & Tilburg 1994 pp. 249-251). In 1989, Max Havelaar bought 800 Mt of coffee from 1,400 farmers in Costa Rica and Guatemala (Wattel et al. 1991; cited in Pelupessy & Tilburg 1994 p. 253), or 0.2% of the exports of both countries (UNFAO 2005). Max Havelaar is still an important fair trade certifying organization for Western Europe (Gresser & Tickell 2002 p. 41).

Since the Max Havelaar initiative, the fair trade industry has grown and matured significantly, and now incorporates a specific set of standards and a fixed floor price based on costs of living and production (TransFairUSA 2004a). The fair trade market and fair trade certification is overseen by Fair Trade Labeling Organizations International (FLO), an umbrella organization in Bonn, Germany (TransFairUSA 2005). Certification standards are developed in concert with producers, traders, and the FLO's member organizations, and include a minimum floor price and numerous social criteria (FLO 2005). Currently, the fair trade floor price for export is \$1.26 per pound, paid to the cooperatives that process the coffee (TransFairUSA 2004b).

There is debate over when the market for fair trade and other "sustainable" coffees will reach saturation. According to Oxfam (2002 p. 41), in 2002 "Fair Trade roast and ground coffee . . . account[ed] for over seven percent of the UK roast and ground market and about two percent of the total coffee market." In 2001, while coffee sales grew by 1.5% overall, sales of fair trade brands grew 12% worldwide, and by 36% in the United States. TransFairUSA (2004a) claims that "81% of Americans say they are likely to switch brands to help support a cause, when price and quality are equal." While they report that in 2003, 18.5 million pounds of fair trade coffee was imported into the U.S. – nearly doubling over the previous year (TransFairUSA 2004b), this represents approximately two-thirds of one percent of all U.S. imports of green and roasted coffee that year (UNFAO 2005). Even Oxfam agrees that fair trade alone cannot solve the coffee crisis or the problem of coffee price volatility, and that wider-ranging solutions are needed (Gresser & Tickell 2002 p. 42).

Additionally, fair trade currently is only available to small farmers who belong to processing cooperatives, and does nothing to address working conditions on larger coffee farms, or prices paid to farmers who sell to private processors. Fair trade may also encourage farmers to continue producing coffee who would be better off, over the long-term, changing to other products that they can produce more competitively.

Another weakness of fair trade may be that it can, in effect, subsidize buyers who pay lower prices. Because cooperatives do not always sell *all* their coffee to fair trade buyers, the coffee sold at fair trade prices may simply raise the average price given to

farmers, without raising that price to the floor level that consumers believe farmers are receiving. For example, in 2003-04, Coopabuena sold 10% of its coffee through fair trade or direct marketing channels (Grosser et al. 2005). This helped to raise the final price paid to farmers above the average paid by cooperatives in Coto Brus, but only by about 9%, to approximately \$0.60 per pound (Fernández & Alvarez 2004).

Dennis Macray* at the Starbucks Coffee Company (pers. comm. 2004) says that the “subsidy” issue is one faced by anyone paying higher-than-average prices for coffee, including specialty roasters. When farmers are receiving high prices for some of their coffee, they can afford to accept lower prices for the rest of it, or to continue producing coffee to sell at those lower prices. In the case of Starbucks, this can happen when a farmer or *beneficio* produces coffee grown at different elevations (as is often the case in areas with steep slopes), which is sold at different prices. In order, therefore, to truly address the structural problems in the coffee market, it is necessary to implement changes that involve the large roasters, who currently buy on the commodities exchanges at the lowest available price.

Specialty coffees

There are essentially two areas in which a coffee producer can compete in the world market: cost or quality. With its relatively high labor costs and living standards compared to other coffee-producing countries, Costa Rica is not in a position to compete on price, and must turn its attention to quality if it wishes to continue producing coffee. While low production costs are of initial advantage to a country entering the coffee market, the best long-term competitive advantages are provided by technology, infrastructure and the availability of trained, knowledgeable people (Pelupessy 1997 p. 7), all of which Costa Rica possesses in abundance.

The market for higher-quality coffee is expanding, and many small coffee-producing nations, including Costa Rica, have pinned hopes on this market. In the late 1990's, high-quality milds represented 30% of demand in the United States, and this demand could grow to 70% over the next century (Pelupessy 1997 p. 7). The Specialty

* Manager, Business Practices, Corporate Social Responsibility, Starbucks Coffee Company

Coffee Association of America reports that, in 2003, specialty coffee accounted for \$1.7 billion, or a third of the \$5 billion U.S. coffee market (TransFairUSA 2004b).

In 2001, the Costa Rican daily *La República* reported that 20% of Costa Rica's coffee was sold through direct contracts (as opposed to the commodities exchanges), at prices nearly double the national average (Prendas 2001a). In 2004, *La Nación* reported that 60% of Costa Rica's higher-quality coffee was sold to the specialty market, receiving average prices of \$1.20 per pound, compared to \$0.80 per pound on the New York Exchange (Barquero S. 2004d).

In July of 1993, the Costa Rican Coffee Institute (ICAFE), the National Autonomous University and the University of Costa Rica sponsored a symposium entitled "Modernization, Technology, Social Change and the Coffee Crisis," to seek public policy solutions to the crisis. For what appeared to be the first time, a long-term reduction in output was discussed (Guevara M. 1993). It was not until 1999, however, after the second price collapse in less than ten years, that the focus of government policy began to seriously shift from quantity to quality. It was in that year that ICAFE began to sign "quality agreements" with various coffee-producing zones (Barquero S. 1999).

In 2001, while the average price was about \$0.70 per pound for Costa Rican farmers, producers of specialty coffees were receiving a minimum of \$1.00. Coffee specialists were arguing by this time that the salvation for Costa Rica's coffee sector would be high-quality specialty coffees, since lower-quality coffees could be produced much more cheaply in other countries. Juan Bautista Moya, director of ICAFE, began arguing that growers who could not find a niche in the specialty market would have to stop growing coffee. A program was begun to promote a Costa Rican brand, much like Colombia's successful "Juan Valdéz" campaign, and to eliminate the production of the lowest quality 5% of Costa Rica's coffee (Mora 2001a).

In 2002 Costa Rica, along with the other Central American countries and the Dominican Republic, signed a "Quality Coffee" agreement with the U.S. Agency for International Development. Through this agreement, USAID would provide funding for:

"a market-based program to assist small and medium coffee producers to improve coffee quality, form new business linkages, secure longer-term contracts with the

specialty coffee industry, and identify and implement diversification options for producers that cannot be competitive.”

Similar programs were being implemented in Africa and Asia (U.S. Agency for International Development 2003).

In 2003, Starbucks sparked excitement in Costa Rica when they announced a plan to increase their purchases of Costa Rican coffee by 150% over four years, to 46,000 Mt, or 42% of Costa Rica’s 2003 production. Starbucks - which purchases 30% of its beans from Costa Rica - was already the country’s largest buyer, paid prices nearly double what is paid on the New York exchange (Rogers 2003), and purchases all its coffee through direct, long-term contracts with growers and processors (Dennis Macray, pers. comm. 2004). Juan Bautista Moya, executive director of ICAFE, remarked that due to Starbucks’ plan “there will no longer be a crisis” (Rogers 2003).

One option for producers who want to enter the specialty coffee market is to work together with their neighbors to develop an “appellation,” or a brand of coffee based on a particular growing region. Coffees have distinctive characteristics based upon where they were grown and processed, much like wines. Many coffee connoisseurs claim to have preferences for coffees from certain regions, and regions that produce distinctive, high-quality coffee are beginning to capitalize on this growing interest in coffee of specific origins. Some well-known appellations that command a price premium include Guatemala Antigua, Hawaiian Kona, and Jamacian Blue Mountain coffee.

While appellation-based brands may be more difficult to establish, due to the high degree of coordination and cooperation required among growers, processors and exporters in a region, they are more stable, because no one outside the appellation region can take over the region’s appellation (Varangis et al. 2003), although counterfeiting is rumored to occur, most notably with Kona and Blue Mountain coffee.

The Costa Rican ICAFE is working to establish appellation brands for its country’s coffees, labeling coffee as belonging to one of seven regions: Tarrazú, Brunca, Orosí, Tres Ríos, Turrialba, Valle Central and Valle Occidental (The Brunca region includes Coto Brus). According to the ICAFE’s web site (www.icafe.go.cr), “All the coffee-producing regions of Costa Rica have joined in signing a quality improvement

agreement, whereby the owners of processing plants in each region undertake to produce coffee of the highest quality.” To qualify to carry one of the Costa Rican appellations, the area where a coffee is grown is required to meet strict requirements for altitude, soils, and precipitation, and the beans must meet standards for hardness, body and acidity (Barquero S. 2004c).

The Costa Rican coffee region Tarrazú provides an example of the benefits that can be realized from a high-quality coffee region establishing its brand. In 2004, coffee carrying the Tarrazú appellation could receive a price premium of \$0.25 to \$0.40 per pound, and a bitter argument was taking place over alleged unauthorized use of the Tarrazú brand name (Barquero S. 2004b). In April 2005, the estate coffee La Candelilla, from Tarrazú, received Starbucks’ “Black Apron Exclusives” quality award, which paid a premium (above the price of the coffee) of \$15,000 for that year’s harvest (Associated Press Costa Rica 2005). In December 2005, La Candelilla coffee was retailing for \$22 per pound at Starbucks’ online store.

Costa-Rica is well-positioned to expand its share of the specialty coffee market, and appears to be reaping benefits for its farmers by doing so. This solution is not an option for many other countries, or indeed for all Costa Rican producers. Areas such as Agua Buena, which have less-than-ideal conditions for coffee, are unlikely to find a place for their coffee in the relatively small specialty market. Additionally, as more producers of high-quality coffee attempt to enter the specialty sector, prices will be driven down. This “fallacy of composition,” or what Oxfam refers to as “running for the same exit,” (Gresser & Tickell 2002 p. 42), is being encouraged by government agencies in producing countries. Although there is awareness of the problem, it seems that, rather than look for other exits, everyone seems to rely instead on the hope that they can get to the exit first.

Supply controls

Pelupessy (1991) stresses the importance of controlling supply, possibly through programs that reduce inputs. Such an approach would have the added benefits of lowering farmers’ costs, thereby insulating them from price swings, and reducing the environmental harm done by coffee production. He also suggests that there is a need to

seriously question whether coffee is an appropriate crop for small producers, given its high capital needs and price volatility.

The question of whether some coffee producers should get out of the market entirely is an important one. Free-market promoters point to the crisis as a market signal to “supply a higher-value product or exit the market” (Lindsey 2003). Orin Smith, former CEO of the Starbucks Coffee Company (which supports an International Coffee Agreement-style quota and price agreement), has been quoted as saying that coffee below 3,500 feet (1,050 meters) in elevation may not be economically viable over the long term, and those farmers should consider changing to other products (Dennis Macray, pers. comm. 2005). As this study has shown, many producers are already taking this step as a logical response to the crisis. This study has also illustrated some of the environmental consequences of such a change, especially when farmers do not receive adequate technical or financial support to change to environmentally sustainable products.

In the era of “free trade,” the prospects for controlling exports through another quota agreement such as the ICA look dim. Even if a new agreement could be reached, it is unlikely that it would be entirely free of the problems that undermined the first four agreements. The experience with ICA, however, points out many ways in which a new agreement could be improved. Most importantly, any new agreement needs to address the problem of over-supply – not simply by limiting exports, which under ICA resulted in the destabilizing accumulation of large stocks, but by addressing supply at the farm level. According to Oxfam, Nestlé stands alone among the top five coffee roasters in supporting supply management, including an ICA-style agreement (Gresser & Tickell 2002 p. 43).

In a Congressional hearing on the coffee crisis in July of 2002, a number of speakers recommended increasing the “purity” standards for coffee imports to the U.S. from an allowed level of 25% adulterants (bad beans, sticks, rocks etc.) to 5%, the level set by the ICO and European countries. U.S. Rep. Sam Farr claimed this would remove 8-10 million bags of coffee from the market, and further encourage a shift to production of higher-quality coffees (U.S. House of Representatives 2002 p. 15).

Of course, plans to limit supply are, in essence, plans to remove some proportion of coffee farmers from the business. When, as is often the case, supply management is

addressed as a quality control issue aimed at removing some percentage of the lowest-quality coffee from the market, it is the farmers in the most marginal areas (where prices are already likely to be the lowest) who will no longer have buyers for their product. As painful as it is, such a result is unavoidable when the problem is, at root, too much coffee.

This thesis has shown some of the environmental results when farmers are driven out of the coffee market, and other authors have discussed the same issue for different localities (Varangis et al. 2003 pp. 54-63). It is therefore essential, from both an environmental and social standpoint, that programs of supply control address the provision of environmentally sustainable alternatives to coffee, and of the financial assistance needed to help with the transition to such alternatives. To address this issue, Oxfam recommends the creation of a diversification fund, to assist producers of lower-quality coffee in finding alternative livelihoods (Gresser & Tickell 2002 p. 49).

Diversification

Diversification is clearly an important component of any plan to address the coffee crisis. Just as investors with a balanced asset portfolio are less vulnerable to stock market swings, a farmer with several crops, at least some subsistence production, and/or off-farm sources of income, will be more shielded from price volatility in the commodities they produce. Unfortunately, when prices of a particular commodity are high (just as when a particular stock market sector is going up), the temptation is great to consolidate resources in that area, rather than forego some temporary profits in the interest of longer-term stability.

The national governments of producing countries, which could play a role in encouraging diversification, are prone to the same financial enticements as farmers. Coffee exports are often an important source of foreign exchange for debt-burdened governments of developing countries (Pelupessy 1993), and it can be difficult to forego some of the additional export tax revenues that can be obtained during periods of high coffee prices. Furthermore, when government agencies do introduce diversification programs, poor planning or lack of ongoing support may undermine the efforts, resulting in reluctance by farmers to work with those agencies in the future.

Some alternative exports that grow well in coffee-producing regions are mango, citrus, and macadamia, but these crops, like coffee, take several years to begin producing, and require intensive marketing to break into the world trade (Viquez 1992a). In Coto Brus, both citrus and macadamia were introduced by the Ministry of Agriculture (MAG) as alternatives or supplements to coffee. Although citrus has been successful for some farmers, and plantain has also provided an alternative income for many, neither yields the same income that coffee once did. One farmer said that the orange cultivar sold to many farmers by MAG was not of export quality, resulting in substantial losses to those who planted it.

Macadamia has been more or less a failure in the region, as sufficient processing and transportation infrastructure and access to markets were not available to farmers in the area, who found themselves unable to sell their harvest. None of the farmers interviewed listed macadamia as a current crop, although several talked about the attempts to introduce it in the *cantón*. The experience of Coto Brus with macadamia underscores the importance of government agencies' working with the private sector to ensure that markets are available for new products.

Vegetable crops, such as tomato and green pepper, require extremely high chemical and labor inputs, making these an unsustainable and environmentally detrimental alternative. Nonetheless, many farmers have been drawn to them for the high profits they offer. Although this was not mentioned during interviews, the annual growth cycle of vegetables, resulting in a short period from planting to sale, is most likely another attraction of these types of crops.

There is also the need to consider that, when introducing any new crop, saturation of the market may result from many producers switching to that product at the same time, driving prices down. The coffee crisis itself is, to some extent, a result of this force – Vietnam introduced coffee to generate foreign exchange for the country, and was successful enough at it to drive coffee producers around the world into bankruptcy. Farmers in Agua Buena frequently mentioned fears that the prices of plantain, citrus, vegetables or beef would fall if more farmers switched to producing these products.

Despite these hurdles, diversification remains key to both addressing the current crisis and insuring against future ones. Many national governments, as well as international agencies, recognize this, although diversification does not appear to be a high priority in any response plan for Central American countries. The U.S. Agency for International Development claims to have included diversification as part of its response to the coffee crisis (USAID 2003; 2004). In 2001, Guatemala established a trust fund to support coffee growers which was intended, in part, to encourage diversification. The other Central American countries, however, appear to have focused their efforts almost entirely on the short-term goals of keeping farmers afloat by supplementing prices (Varangis et al. 2003 p. 27).

3. Conclusion

The current crisis facing coffee producers worldwide is structural in nature, the result of significant changes in world markets and production dynamics. In response to the crisis, coffee farmers who have not been able to either sufficiently cut costs or access higher-value sectors of the market are being forced to abandon coffee production. In the district of Agua Buena, Costa Rica, farmers are either abandoning their land or changing to other crops, with the predominant conversion choice being pasture. The conversion from coffee to pasture is having significant effects on the richness, diversity and community composition of resident birds that utilize the agricultural matrix. The relationship between the coffee crisis and environmental effects is complex, but the apparent habitat loss and urbanization associated with the crisis are causes for concern.

A number of responses to the crisis are available at the international level. None of them is simple and none of them, taken in isolation, will solve all the problems created by the crisis. Improvement of coffee quality and expansion of the specialty market; the varieties of certified coffees, particularly fair trade; price and quota agreements resembling the International Coffee Agreement; and diversification are all components of a strategy to deal with the economic and environmental impacts of the crisis.

Perhaps the most important, and the most overlooked, element of an effective response to the crisis is the provision of economically and environmentally sustainable alternatives for those producers in geographical areas that are not ideally suited for

growing coffee. Programs of supply reduction or quality improvement that leave farmers to “sink or swim” without transitional assistance are certain to have negative effects on the environment, as well as the social fabric, of the areas that are cut out of the coffee market. Conversely, fair trade programs need to address the appropriateness and competitiveness of coffee as a product for a given area, and address the issue of diversification for long-term financial stability.

Finally, conservation groups focused on coffee-producing countries need to understand the importance of focusing attention on this issue, and cooperating with governments and NGO’s to find viable solutions that address the environmental implications of coffee price instability. Resolution of the coffee crisis is of environmental as well as social and economic importance.

Glossary

Beneficio: A facility that processes fresh coffee cherries into green coffee.

Cajuela: Twenty liters of fresh coffee cherries. Coffee pickers are paid by the number of cajuelas they collect. Twenty cajuelas equal one fanega.

Charrál: Pasture in a state of early abandonment or overgrowth, characterized in the Agua Buena region by mostly woody vegetation averaging 1-2 meters in height; potentially an early stage of forest regeneration.

Colón: The unit of currency in Costa Rica. In 2003 one dollar was equal, on average, to 410 colones.

Coyote: 1. A middleman who purchases raw coffee cherries from farmers and transports them to a *beneficio*. 2. Someone who transports or arranges transport of persons to the United States, usually illegally.

Fanega: Four hundred liters of fresh coffee cherries. Coffee growers are paid by the number of *fanegas* they bring to a processor. In Costa Rica, processing yields average around 100 pounds of dry green coffee from each *fanega* of fresh cherries. Processing yields in Coto Brus average 96 pounds. (ICAFE 1993)

Gallery forest: A forest along a river or stream.

Green coffee: Dried coffee beans that have had the pulp and “silver skin” removed. Most coffee is exported as green coffee.

ICA: The International Coffee Agreement.

ICAFE: The Costa Rican Coffee Institute, which regulates the coffee trade within the country.

ICO: The International Coffee Organization.

Parchment: The thin membrane, papery when dry, that separates the coffee bean from the pulp of the coffee cherry.

Quintal: Forty-six kilograms, or 100 pounds, of dry green coffee. The standard unit of measure for exports from Costa Rica. (ICO uses sacks of 60 kg).

Recibidor: One of many small collecting stations for ripe coffee cherries stationed around the Costa Rican countryside.

Appendices

Appendix A. Additional information regarding interviews

Questionnaire for landowners

1. How old are you?
2. How many years of education do you have?
3. How many years have you had your farm?
4. How many years have you lived in the area?
5. How many hectares do you have?
6. How many of those are yours, and how many do you rent?
7. How did you acquire your land?
8. How many hectares are in coffee, pasture, forest, annual crops, or other uses?
9. What do you grow on your farm (include items for personal consumption).
10. What is your income per year? (If they don't know, ask questions about sources of income and amount from each source, to allow for an estimation of annual income).
11. Do you have other sources of income besides coffee? What are they, and how much to you earn from each?
12. Do you want your children to also be farmers?
13. Do you belong to any agricultural organizations? Which ones?
14. Do you attend meetings of any agricultural organizations? How many per year?
15. Have you cut out any of your coffee in the last 6 years?
16. When did you cut it out?
17. How much did you cut out?
18. Why did you cut it out, or if you kept it, why did you keep it?
19. What did you do with the land where the coffee was? What are your plans with the land? Why?
20. How many people work on your land? How many family members work on your land? Do the workers live on or off the farm?
21. How many family members live with you?
22. Have some children or other family members left the community? Why?
23. How much did you receive per fanega for the last coffee harvest?
24. How many fanegas did you sell during the last harvest?
25. What price would you need for coffee to be profitable for you? (Also asked: What coffee price would you need for it to be worthwhile to grow coffee?)
26. What is the highest price you remember getting for your coffee? What year was that?
27. Do you use any agrochemicals? What types?
28. Are you going to stay on your land, or do you have plans to leave? Why? If you leave, what do you plan to do? What are your plans if you do stay?
29. What do you cook with?
30. Do you think there will be enough fuelwood if you convert your land from coffee to another use? What will you do if there isn't enough?

31. If you have changed from coffee to another land use, do you use fewer or more agrochemicals? Does your land require more or less work?
32. If you are going to keep growing coffee, will you continue with conventional coffee or do you have plans to change to other cultivation methods (like sustainable or organic). Why, or why not?
33. Where or from whom do you obtain technical advice on methods of growing?
34. Where or from whom do you obtain information about prices and marketing?
35. Do you use credit or borrowed money to finance your production?
36. If you use credit, does your lender require any special practices by you before making the loan?
37. What types of birds do you recognize in your farm?
38. Have the types of numbers of wild animals on your farm changed over the years? How have they changed? If they have changed, do you have an idea as to why?

Excluded data

One interviewer, the author of this thesis, was a North American female, fluent in Spanish, who had lived for a year in Costa Rica. The other interviewer was a Costa Rican female, born and raised in the Agua Buena area. Both interviewers conducted surveys in the same neighborhoods, with the North American interviewer conducting surveys of farmers on one side of a street and the Costa Rican conducting surveys on the other side. The North American interviewer completed 38 interviews and the Costa Rican interviewer conducted 21. All answers were grouped by interviewer and tested using *t*-tests or χ^2 tests to determine if any bias was introduced to the question by the interviewer.

Table A.1 summarizes the variables that showed a significant difference in responses based on interviewer. The fourteen variables that showed a significant difference between interviewers can be broken into two groups. The first group consists of variables, such as age or number of hectares of a specific land use, that are unlikely to be subject to cultural influence or other forms of interviewer bias; i.e., differences in these variables are probably due to chance. The second group consists of qualitative or opinion-based questions that are more likely to be subject to bias.

The questions regarding age, number of hectares abandoned, and number of family members working on the farm are qualitative questions not likely to be subject to interviewer bias. For example, there is no readily apparent reason why respondents would over- or under-report their age to either interviewer. Additionally, the differences

for the latter two variables, while statistically significant, are small. It is therefore likely that the differences in these variables are due to chance, and none of these data are excluded from the analysis.

Number of years of education showed a significant difference between interviewers, with respondents interviewed by the North American reporting, on average, an additional 1.5 years of education. While it is conceivable to imagine that respondents might be over-reporting education to the North American interviewer, educational level was also significantly negatively correlated with respondent age ($r = -0.524$, $N=58$, $p=0.000$). The average respondent age was 10 years higher for the Costa Rican interviewer ($t=-2.270$, $df=55$, $p=0.027$), a result that is probably due to chance. For the purposes of this study, it will be assumed that the educational differences are a result of age, and not of interviewer bias.

The respondent's spouse participated in 100% of interviews conducted by the Costa Rican, and only 53.8% of those conducted by the North American ($\chi^2=14.400$, $df=1$, $p=0.000$). Spouse participation, however, was not significantly correlated with any other interview variable. This difference is therefore not important for the purposes of this study.

Nearly all (91.3%) of the respondents reported an annual income to the North American interviewer, while only one third (33.3%) reported an annual income to the Costa Rican interviewer ($\chi^2=21.564$, $df=1$, $p=0.000$). This difference may be due to respondents' discomfort in discussing income with a community member, but also probably has to do with relative interviewer effort. When respondents told the North American interviewer they didn't know their income, the interviewer would review their various income sources and question respondents about amounts received from each. Discussions with the Costa Rican interviewer revealed that in most cases, when a respondent told her they didn't know their income, she accepted the answer and did not ask follow-up questions.

While total annual income for respondents who reported it was not significantly different between interviewers ($t=1.207$, $df=38$, $p=0.235$), significantly fewer (73.7% vs. 94.6%, Fisher's Exact Test, $p=0.038$) reported sources of income besides coffee to the

Costa Rican interviewer. This is probably due to the difference in interviewer effort described above. For example, many respondents did not report remittances or pensions until specifically asked about them, and it was not clear whether the Costa Rican interviewer consistently asked about specific income sources. Therefore, despite the fact that income numbers themselves are not significantly different between interviewers, the income data from the North American interviewer are likely to be more complete, and data from the Costa Rican interviewer are excluded from the analysis. Information on sources of income is included, however, as this is qualitative information that may be of interest despite being potentially incomplete.

The question of what price coffee would need to reach in order to be worthwhile was actually worded in two separate ways by the two interviewers. While the Costa Rican interviewer, who received higher values on average, asked the question as written: “What coffee price would you need for it to be worthwhile to grow coffee,” due to language issues the North American interviewer actually phrased the question as, “What price would you need for coffee to be profitable for you.” Thus, the difference in these responses may indicate that a price that would allow farmers to turn a profit may not be enough to make coffee worthwhile for them to grow. The responses for each interviewer are treated separately in this case, but neither set was discarded.

The question concerning the year of the highest coffee prices is probably related, again, to the average age of the sample, as the mean year reported to the Costa Rican interviewer (1992) was significantly lower than that reported to the North American interviewer (1997, $t=3.429$, $df=28.245$, $p=0.002$), and age was significantly negatively correlated with the highest price year in memory ($r= -0.392$, $N=54$, $p=0.003$). The mean for highest price in memory was much larger in the Costa Rican interviewer’s group, though not significantly so (\$230 vs. \$132, $t=-1.965$, $df=27.427$, $p=0.060$). The highest prices in respondents’ memories, however, were also closely negatively correlated with the year in which respondents reported receiving that price ($r=-0.890$, $N=50$, $p=0.000$), but not significantly correlated with age ($r=0.171$, $N=49$, $p=0.239$).

Additionally, some values reported during interviews were exceptionally high, reaching over \$550/*fanega* (over \$5/pound) for both interviewers, for years in which the

world export price for other milds was only around \$2/pound. The responses to this question, in order to enable comparison, had been converted based on the exchange rates and inflation factors for the year in which the price was received, but it is not clear whether all respondents reported prices in the currency actually received at the time of sale, or mentally “converted” the prices into contemporary equivalents. It appears that a mixture of these two options occurred, but there is no way to reliably separate the responses based on this factor. Thus, these data are not reliable and are excluded from analysis.

The remaining four variables in Table A.1 are qualitative questions that could conceivably show a cultural bias. Discussions with the Costa Rican interviewer regarding her expectations for these questions, and her belief as to the likely responses, and the overall lack of variation in responses recorded by the Costa Rican vs. the North American interviewer, lead to the conclusion that the Costa Rican interviewer may have been coaching respondents or otherwise biasing the responses to these four questions. Therefore, data from the Costa Rican interviewer are excluded from analysis of these variables.

In short, six variables are wholly or partially excluded from analysis, as follows:

1. Annual Income (Costa Rican interviewer)
2. Highest coffee price in memory (both interviewers)
3. Outside sources of information on technology and farming practices (Costa Rican interviewer)
4. Outside sources of information on price (Costa Rican interviewer)
5. Change in numbers or species of animals over time (Costa Rican interviewer)
6. Reason for perceived changes in fauna (Costa Rican interviewer)

Figures and Tables

Variable	US Interviewer	CR Interviewer	df	Statistic	Sig.
Spouse participated in interview	53.8%	100%	1	$\chi^2=14.400$	0.000
Age of interviewee	50.8(mean)	60.81(mean)	55	$t= -2.270$	0.027
Years of education	4.5(mean)	3.0(mean)	54.9	$*t=2.127$	0.038
Did not report annual income	8.3%	66.7%	1	$\chi^2=21.564$	0.000
Reported other sources of income besides coffee	94.6%	73.7%	N/A	Fisher's Exact Test	0.038
Number of hectares of coffee abandoned	0.7	0.1	38.4	$*t=2.483$	0.018
Number of family members working on farm	1.0(mean)	1.4(mean)	56	$t= -2.414$	0.019
Price that coffee would have to reach to make it worthwhile to grow	\$66.19	\$82.03	51.7	$*t= -5.054$	0.000
Year of highest price in memory	1997(mean)	1992(mean)	28.3	$*t= 3.429$	0.002
Reported no outside source of technical information	35.1%	90.5%	1	$\chi^2=8.068$	0.005
Reported no outside source of price information	35.1%	100%	1	$\chi^2=23.237$	0.000
Believe there are fewer species/individuals of animals now than before	51.4%	100%	1	$\chi^2=14.060$	0.000
Listed hunting as primary reason for faunal change	17.6%	93.3%	1	$\chi^2=18.331$	0.000

Table A.1. Interview variables that showed a significant difference between interviewers. Where Levene's test for equality of variances was significant at $p<0.05$, the t statistic with equal variances not assumed was used. These t values are marked by an asterisk. Fisher's Exact Test was used where χ^2 was not appropriate due to low expected values.

Perceived changes in fauna		
Animals of which respondents have observed more since arriving in the area	Armadillos	2 (3.4%)
	Birds	2 (3.4%)
	Clay-colored Robins	2 (3.4%)
	Guans	2 (3.4%)
	Agoutis	1 (1.7%)
	Chachalacas	1 (1.7%)
	Doves	1 (1.7%)
	Grackles	1 (1.7%)
	Gray-necked Wood-rail	1 (1.7%)
	Hummingbirds	1 (1.7%)
	Monkeys	1 (1.7%)
	Mot-mots	1 (1.7%)
	Sloths	1 (1.7%)
	Squirrels	1 (1.7%)
	Tanagers	1 (1.7%)
	Toucans	1 (1.7%)
Animals of which respondents have observed fewer since arriving in the area	Agouti	7 (11.9%)
	Armadillos	3 (5.1%)
	Clay-colored Robins	3 (5.1%)
	Oropendulas	3 (5.1%)
	Peccaries	3 (5.1%)
	Coati	2 (3.4%)
	Doves	2 (3.4%)
	Flycatchers	2 (3.4%)
	Jays	2 (3.4%)
	Monkeys	2 (3.4%)
	Parrots/parakeets	2 (3.4%)
	Racoons	2 (3.4%)
	Squirrels	2 (3.4%)
	Tapirs	2 (3.4%)
	Toucans/toucanets	2 (3.4%)
	Anis	1 (1.7%)
	Chachalacas	1 (1.7%)
	Deer	1 (1.7%)
	Foxes	1 (1.7%)
	Guans	1 (1.7%)
	Insects	1 (1.7%)
	Jaguars	1 (1.7%)
	Macaws	1 (1.7%)

Table A.2. Animals for which respondents have perceived a change in abundance since arriving in the study area.

Perceived changes in fauna (cont.)		
Animals of which respondents have observed fewer since arriving in the area (cont.)	Mammals	1 (1.7%)
	Ocelots	1 (1.7%)
	Owls	1 (1.7%)
	Paraques	1 (1.7%)
	Snakes	1 (1.7%)
	Tanagers	1 (1.7%)
	Tinamous	1 (1.7%)
	Woodpeckers	1 (1.7%)

Table A.2. Continued.

All farm products reported		
Coffee	41	(69.5%)
Plantain	36	(61.0%)
Corn	24	(40.7%)
Yucca	23	(39.0%)
Beans	22	(37.3%)
Orange	21	(35.6%)
Milk	17	(28.8%)
Squash	15	(25.4%)
Beef	14	(23.7%)
Banana	12	(20.3%)
Tequisque	12	(20.3%)
Sugar cane	9	(15.3%)
Greens	8	(13.6%)
Pigs	5	(8.5%)
Chicken	3	(5.1%)
Chili	3	(5.1%)
Lime	3	(5.1%)
Other crops	3	(5.1%)
Tomato	3	(5.1%)
Calves	2	(3.4%)
Cheese	2	(3.4%)
Cilantro	2	(3.4%)
Lumber	2	(3.4%)
Nampi	2	(3.4%)
None	2	(3.4%)
Radishes	2	(3.4%)
String beans	2	(3.4%)
Caña india	1	(1.7%)
Cas	1	(1.7%)
<i>Inga</i> spp.	1	(1.7%)
Jocote	1	(1.7%)
Lemon	1	(1.7%)
Mamones	1	(1.7%)
Mango	1	(1.7%)
Medlar	1	(1.7%)
Pineapple	1	(1.7%)
Sweet potato	1	(1.7%)
Tilapia	1	(1.7%)
Water apple	1	(1.7%)
Zacate	1	(1.7%)

Table A.3. All products reported by farmers, with number and percentage of farmers who reported each product.

Appendix B. Additional information regarding bird surveys

Site Descriptions

Pasture 1.

This site belonged to the Corporación Cafetalera La Meseta, and was part of a several hundred-hectare coffee plantation that was being converted to pasture. The site was maintained by paid workers and a paid manager. According to field workers at the site, the coffee had been removed following the 2001-2002 harvest and the site was treated with the herbicide glyphosate, then planted with high-yielding pasture grasses. At the time of the surveys, the pasture grasses were mixed with weeds at an estimated cover of 10-40%. The original shade cover was *Erythrina spp.* The trees had been pollarded to an approximate height of 1-2m following clearing, but had re-sprouted to form dense, leafy bushes or trees ranging from 2-10 m tall. No other trees inhabited the site. The site was bordered on one side by coffee fields that had been completely cleared (cut down and treated with herbicides) less than a month before, on one side by habitat similar to the site itself, and on two sides by gallery forest. No agrochemicals were used on the site during the year preceding the surveys. No cattle were present on the site during the survey period.

Pasture 2.

This site was managed by the owner and one paid worker, and was part of 70 ha belonging to the landowner. It was cut following the 1997-98 harvest and low-growing, tangling grasses covered the site at the time of the surveys. The original shade cover was poró and *Musa spp.*, and most trees were left when the coffee was cleared. The remaining poró trees were in poor condition, most being 1-2m tall and resembling sparse bushes. A very narrow (less than ½ m wide) stream ran through the site, and areas near the stream were swampy. A 1m strip along the stream was inhabited by shrubby (2-3m) vegetation. One tall (~5m) orange tree, one small (2-3m) orange tree and one tall (7-10m) *Inga spp.* tree grew on the site. The site was bordered on one side by a dirt road, on one side by houses, on one side by a row of pine trees next to a dirt road, and on one side by gallery forest. There were two downed pine boughs on the site, near the pine trees. Approximately a dozen cattle were present on the site during the final survey. According

to the site's owner, no agrochemicals had been used at the site during the year preceding the surveys.

Pasture 3.

This site was managed by the brother of the owner, and was part of a 3-ha farm. It was cleared of coffee following the 2001-2002 harvest, planted with a mixture of the hybrid grasses “Bombasa,” “Brisanta” and “Bracaria,” and treated with the broad-leaved herbicide Tordon. The owner had not used any agrochemicals since this initial treatment. The original shade cover had consisted of orange trees, *Musa spp.* and *Erythrina spp.* The *Musa spp.* trees remained and were in good condition. Most of the orange trees had been cleared, with only a small grove of 4 trees remaining, and the *Erythrina spp.* trees had been thinned to approximately half the original density. The remaining *Erythrina spp.* trees had been damaged by cows browsing bark from the lower trunks, and had very little foliage left, though many had grown quite tall (5-10m). No other trees inhabited the site. The site was bordered on one side by gallery forest, on one side by a caña india (*Dracaena fragrans*) fence next to a dirt road, on one side by a *Eucalyptus* plantation and on one side by pasture. Twelve cattle were contained in this pasture during the survey period, and were present during every survey.

Pasture 4.

This site was managed by the sons of the owner, and was part of an 8-ha farm. It was cleared of coffee following the 2001-2002 harvest, planted with high-yielding pasture grasses and treated with Tordon. The ground was covered by an estimated 70% pasture grasses and 10% weeds with approximately 20% bare soil. The original shade cover had consisted of *Erythrina spp.* and *Musa spp.* A cluster of three tall second-growth trees inhabited the site, including one *Inga spp.* The poró trees remained on half the site and were about 3 m tall with wide, branching crowns and sparse foliage. The *Musa spp.* trees remained on the other half of the site and were in good condition. This 5-sided site was bordered on two sides by tall (~10 m), mixed species living fences next to dirt roads, on one side by a caña india fence next to a dirt road, and on two sides by pasture separated by a fence of widely-spaced, very small and sparse *Erythrina spp.*

Cattle were present during two surveys. Tordón was sprayed once during the survey period.

Coffee 1.

This site was managed by paid workers and was part of a 30-hectare farm. The site had a mixed shade cover of *Erythrina spp.*, *Musa spp.* and *Citrus spp.* Rows of *Dracaena fragrans* were planted along the contour of the hill and along the sides of the two paths that ran through the plantation. One tall (over 30 m), primary forest tree inhabited the site with four smaller (~10m) secondary forest trees. The primary forest tree supported lianas and other epiphytes. The site was bordered on one side by swamp and gallery forest, on one side by a *D. fragrans* fence next to a dirt road, on one side by a tall (~10 m), mixed species living fence next to pasture, and on one side by a *D. fragrans* fence next to pasture, vegetable crops and a coffee nursery. These trees were in poor condition but still alive, with sparse foliage. According to the spouse of the site's owner, no agrochemicals had been used at the site during the year preceding the surveys.

Coffee 2.

This site was managed by the owner and was part of a 6 ha farm. The site had a mixed shade cover of *Erythrina spp.* and *Musa spp.* The poró had been heavily pollarded and had small, dense heads of foliage. One orange tree was present at the site. Four tall (approximately 10 m), secondary forest trees inhabited the site. Three of these were in good condition with dense foliage, while the fourth was in poor condition with sparse foliage. The site was bordered on two sides by gallery forest, on one side by houses and gardens, and on one side by a house and a dirt road. No agrochemicals had been used at the site during the year preceding the surveys.

Coffee 3.

This site consisted of plots from two adjacent farms. Both farms were managed by the owners. One of the owners owned a 6 ha farm, and the other owned a 2 ha farm. Both sites had a mixed shade cover of *Erythrina spp.* and *Musa spp.* One plot was planted with 4 *Terminalia amazonia* trees at the top of a slope, and the other was planted with *D. fragrans*, mixed with the other shade cover. One plot was bordered on one side by gallery forest, on one side by a tall (~10 m), mixed species living fence next to

pasture, on one side by a garden, cornfield and house, and on two sides by coffee plots that had been cut and burned after the 2002-2003 harvest. The second plot was bordered on one side by a poró fence next to a dirt road, on one side by a tall (~10 m), mixed species living fence next to a driveway and pasture, on one side by a tall (~15 m), mixed species living fence next to another coffee plot, and on one side by a dense mixed-species fence covered in a tangle of vines. The ground of the first plot was treated with glyphosate during the survey period. The second plot was partially cleared of weeds by machete during the survey period.

Coffee 4.

This site was managed by paid workers and was part of the same 30-hectare farm as Coffee 1. The site had a mixed shade cover of *Erythrina spp.*, *Musa spp.* and *Citrus spp.* Rows of *D. fragrans* were planted along the sides of the path that bisected the plantation. Three tall (over 30 m), forest trees inhabited the site. These trees were in very good condition with large, leafy crowns. The site was bordered on one side by gallery forest, on one side by a *D. fragrans* fence next to a dirt road, on one side by a *D. fragrans* fence next to a former coffee plot that had been cleared for pasture following the 2002-2003 harvest, and on one side by a tall (~15 m), mixed species living fence next to pasture. The site was partially cleared of weeds by machete during the survey period.

Error Sources

The observe (this author) had 3 months previous birding experience in Costa Rica, and spent an additional 6 weeks prior to the start of the surveys learning to recognize the birds in the survey area by sight and sound, including attending two days of mist-netting and spending three days in the field with regionally-experienced birders. The learning process continued, however, over the course of the surveys, as the observer's ability to identify birds continued to improve. There are, therefore, likely to be more misidentified and unidentified birds in the earlier surveys than in the later ones. This source of error was minimized by scheduling the surveys in cycles, so that the six surveys of each plot were all spread out equally over the 1-month survey period (Table B.1). Thus, any bias will apply equally to all sites and to both habitat types.

Working in the study area from 1998-2000, Lindell et al. (2004) found that point counts were likely to underestimate manakins (Pipridae) and hummingbirds (Trochilidae) compared to mist-netting, while point counts were more likely than mist-netting to detect flycatchers (Tyrannidae). The biases inherent in point counts are likely to apply to the area-search method, as well. Lindell et al.'s study was a comparison between the results of two techniques, not between either technique and the actual abundance of any species group. Ideally, more than one method would be used, but time and resources made this not possible for this study. Point-counts are more accurate at censusing vocal and conspicuous birds rather than smaller, less conspicuous birds.

While the area-search method has the benefit of the observer being able to seek out birds and flush them when necessary, it is still likely to, like point counts, underestimate more cryptic birds. Dieni and Jones (2002) found that the area-search method provided less complete information about species composition in more complex habitat. Since coffee is more structurally complex than pasture, it is likely that the area searches underestimated species richness to a greater degree in coffee than in pasture, lowering power for any tests of differences between the two habitat types. Dieni and Jones, however, spent only 60 minutes in each of their plots, compared to 180 minutes in each of the sites for this study. Thus, these surveys likely provide more complete coverage and a better characterization of the species composition.

There was a large discrepancy between plot sizes, with areas, as calculated by GPS data, ranging from 5637 m² to 18957 m². These area calculations, while the most accurate possible, do not take into account the steep slopes at many of the plots, some of which were estimated as up to 25%. To test for the effect of plot size on the data, Pearson's *r* was calculated between plot size and observed species richness, and was found to be not significant at the $p < 0.05$ level ($N=8$, $r = -0.124$, $p = 0.647$). This was true also when the habitat types were analyzed separately ($N=4$; Pasture $r = -0.438$, $p = 0.278$; Coffee $r = 0.546$, $p = 0.161$). This is probably because, while it would be expected that more species would be seen in a larger plot, the survey effort was kept constant across all plots by using timed searches.

In addition, to ensure that any bias arising from varying plot sizes not detected in the above test would be distributed evenly between habitat types, a 2-tailed *t*-test was performed for site sizes and plot sizes vs. habitat type. Neither test showed a significant association at $p < 0.05$ between habitat type and plot size ($t = 0.667$, $df = 14$, $p = 0.515$) or site size ($t = -0.138$, $df = 14$, $p = 0.895$).

John D. Alexander^{*} (pers. comm., 2003) recommends that sites for bird surveys be chosen at least 250m apart from one another to avoid double-counting of individuals. This goal was not achievable for all sites, due to logistical constraints and the difficulty in finding homogeneous patches of habitat large enough to survey. Pasture 4 was less than 250m from Coffee 3, Coffee 4 and Pasture 3, and Pasture 3 was less than 250m from Coffee 3.

The effect of double-counting individuals that moved between sites would be to under-estimate any differences between sites. In the case of different habitats (coffee and pasture) this would tend to result in an increased Type II error rate, but also a decrease in the Type I error rate. Thus, the proximity of Pasture 3 to Coffee 3, and of Pasture 4 to Coffee 3 and 4, means that any statistical tests comparing pasture to coffee will be less likely to detect a real change in fauna, but also less likely to report a false result, making the tests more robust. In other words, a statistical test showing a significant difference between sites would have a higher probability of reflecting a real difference between sites than that reflected by the *p* value.

The proximity of Pasture 3 to Pasture 4 will have the opposite effect: if individuals moving between the two sites are double-counted, it would result in less variation among pasture sites than if the sites were truly independent. This would increase the Type I error rate and make the statistical tests less accurate.

To determine the importance of these effects, the Classic Sorensen similarity index and Chao-Sorensen similarity estimator were calculated for each pair of pasture sites (Table B.2). To calculate any similarity index, all 12 samples from each site had to be pooled, which would result in double-counting of many individuals during separate surveys if abundance data were to be used. The Classic Sorensen index and Chao-

^{*} Director, Klamath Bird Observatory

Sorenson Incidence-Based Estimator were therefore chosen because they are independent of abundance data (Colwell 2005a), and rely only on presence or absence of each species in each survey. The Classic Sorensen similarity index relies only on species actually observed in the sample, while the Chao-Sorensen similarity estimator relies on a calculated estimate of all species expected to be in the sample based on observed species.

Pearson's r was calculated using the minimum distance between sites (i.e., the distance between the two nearest edges of the sites as determined by GPS data) as the independent variable and the Sorensen Classic index and Chao-Sorensen estimator as dependent variables. The test was repeated for all site pairs, for site pairs of differing habitat types, for pairs of similar habitat types, and for all site pairs plus within-site plot pairs (i.e., plots A and B for each site, with distance set at zero). See Table B.3 for results.

The Sorensen Classic index was significantly correlated with distance only for all sites combined, with within-site similarity included. The Chao-Sorensen estimator was also significantly correlated with distance in this case, as well as for site pairs of differing habitats. These results indicate that distance between sites will bias the results, but that the effect of this bias will be to lower the Type I error rate and increase the Type II error rate. Thus, the surveys are less likely to detect a real difference between habitat types (i.e., power is lowered), but any statistically significant difference detected can be considered to be robust.

Figures and Tables

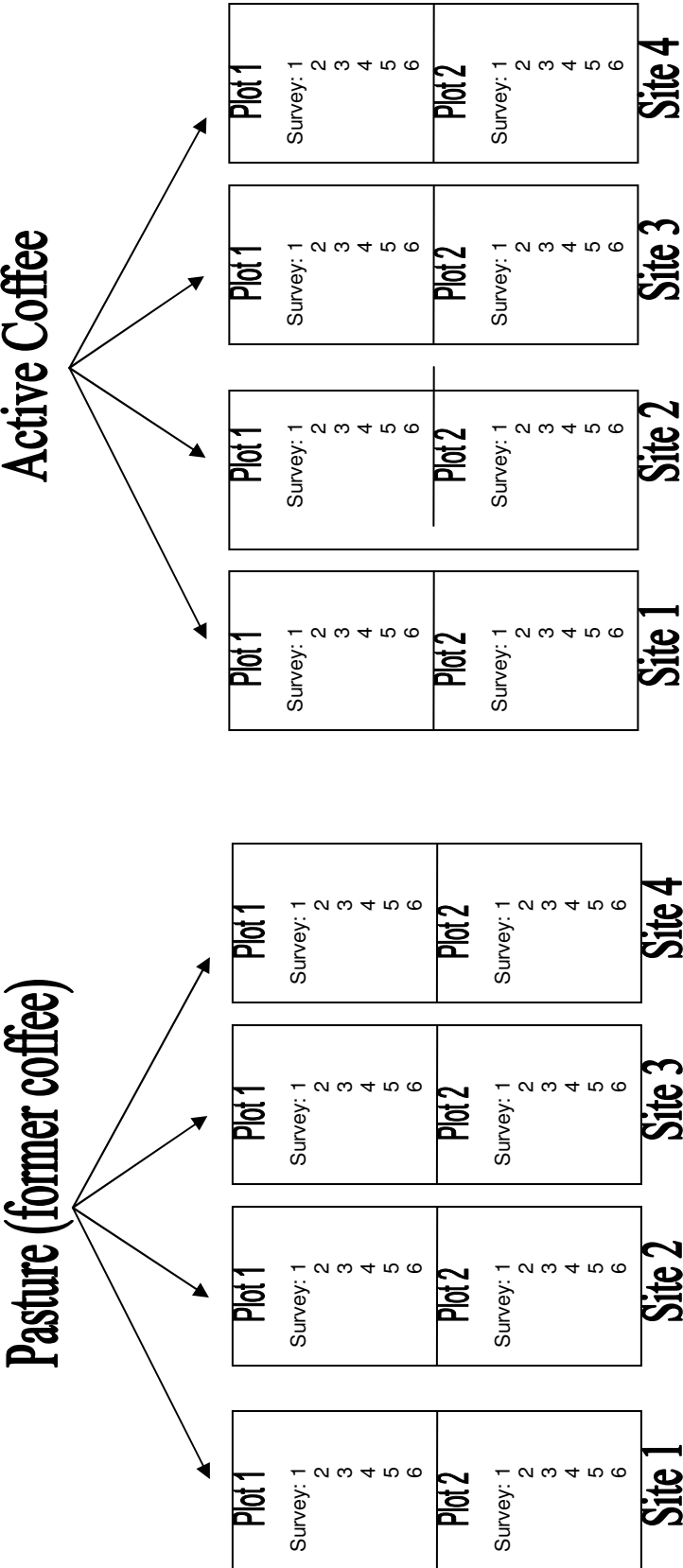


Figure B.1. Survey design.

	8/18	8/24	8/25	8/27	8/28	8/30	8/31	9/1	9/3	9/4	9/5	9/6	9/7	9/8	9/9	9/10	9/11	9/12	9/13	9/14
P1a		8:22				5:34				6:00				7:58		8:18		5:15		
P1b			7:45			6:09				5:41				7:41		8:01		5:32		
P2a		7:50							5:20		8:14			6:33		6:39				7:50
P2b		8:07							5:38		7:57			6:49		6:55				8:07
P3a								7:00	8:29		5:35	8:19				5:40			6:23	
P3b								6:39	8:07		5:16	8:37				5:57		7:46		
P4a				8:00							5:58				8:18		6:24		7:04	6:04
P4b				7:10				5:55				7:58				5:15		8:11	6:47	
C1a		7:04							6:27				5:15		7:25		8:37		5:17	
C1b		6:28						8:27	7:00				5:35		7:05				5:41	
C2a	7:57						6:40	8:00		8:19			6:01				7:54			
C2b		5:52					7:00		7:35				6:19		6:38		8:10			
C3a				5:20				7:26		8:50		8:58		5:15			6:00			
C3b				5:43	8:56			6:18						5:34			7:28			7:00
C4a				8:27				5:31			6:23						7:00		7:56	5:39
C4b								5:15			6:40	7:31			8:48				7:55	5:24

Table B.1. Schedule of bird surveys.

Pair	Distance	Sorensen Classic	Chao-Sorensen-Est Incidence-based
P1	0	0.788	0.894
P2	0	0.638	0.944
P3	0	0.81	0.926
P4	0	0.615	0.864
C1	0	0.792	0.929
C2	0	0.638	1.000
C3	0	0.64	0.944
C4	0	0.72	0.856
P1-P2	2154	0.654	0.859
P1-P3	1335	0.622	0.778
P1-P4	1418	0.596	0.748
P2-P3	1088	0.632	0.834
P2-P4	1442	0.746	0.918
P3-P4	121	0.615	0.849
C1-C2	573	0.754	0.973
C1-C3	1098	0.667	0.837
C1-C4	845	0.787	0.944
C2-C3	566	0.788	0.963
C2-C4	695	0.844	0.973
C3-C4	442	0.788	0.928
P1-C1	2395	0.49	0.522
P1-C2	1718	0.577	0.722
P1-C3	1184	0.593	0.724
P1-C4	1730	0.577	0.577
P2-C1	1120	0.557	0.677
P2-C2	730	0.656	0.888
P2-C3	1361	0.636	0.806
P2-C4	1589	0.656	0.74
P3-C1	891	0.519	0.547
P3-C2	322	0.561	0.754
P3-C3	18	0.61	0.733
P3-C4	388	0.596	0.68
P4-C1	896	0.536	0.729
P4-C2	527	0.678	0.892
P4-C3	162	0.656	0.826
P4-C4	193	0.61	0.715

Table B.2. Similarity indexes for all site pairs, and for plot pairs within sites.

Comparison type	Mean		Pearson corr.:		Sig.		Pearson corr.:		Sig.	
	Distance	N	Sorensen Classic	(2-tailed)	Chao-Sorensen	(2-tailed)	Chao-Sorensen	(2-tailed)	Chao-Sorensen	(2-tailed)
Differing habitat type (pasture vs. coffee)	952	16	-0.407	0.118	*-0.499	0.049				
Same habitat type (e.g., pasture vs. pasture)	981	12	-0.389	0.211	-0.463	0.129				
All site pairs	964	28	-0.272	0.168	-0.350	0.068				
All site pairs, plus plot pairs within sites	750	36	*-0.363	0.029	*-0.510	0.001				

Table B.3. Pearson correlation coefficients comparing distance with the Sorensen Classic similarity index and Chao-Sorensen Incidence-Based Estimator. Correlation coefficients with an asterisk* are significant at the p=0.05 level.

References

- Aguilar, B. J. 1992. Consequences of the Suspension of Economic Clauses in the International Coffee Agreement: A Free Coffee Market? University of Georgia, Athens, GA.
- Albertin, A., and P. K. R. Nair. 2004. Farmers' perspectives on the role of shade trees in coffee production systems: An assessment from the Nicoya Peninsula, Costa Rica. *Human Ecology* **32**:443-463.
- Alfaro, B. S. 1992. Ante la crisis cafetalera. *La Nación*, San José, Costa Rica, August 9.
- American Ornithologists Union. 2005. List of the 2,037 bird species (with scientific and English names) known from the A.O.U. check-list area. American Ornithologists Union, McLean, VA. <http://www.aou.org/checklist/birdlist46.pdf>. Accessed November 30, 2005.
- Anonymous. 1992a. Crisis social y caficultura. *La República*, San José, Costa Rica, July 25.
- Anonymous. 1992b. La Crisis: de mercado y estructura. *La Prensa Libre*, San José, Costa Rica, February 11.
- Anonymous. 1995. La crisis del café. *La Prensa Libre*, San José, Costa Rica, July 8.
- Anonymous. 2002. Crisis del café con efectos explosivos. *La República*, San José, Costa Rica, May 22.
- Anonymous. 2005. Starbucks premia a productores costarricenses de café orgánico. *La Nación*, San José, Costa Rica, August 11.
- Antongiovanni, M., and J. P. Metzger. 2005. Influence of matrix habitats on the occurrence of insectivorous bird species in Amazonian forest fragments. *Biological Conservation* **122**:441-451.
- Arellano, L., M. E. Favila, and C. Huerta. 2005. Diversity of dung and carrion beetles in a disturbed Mexican tropical montane cloud forest and on shade coffee plantations. *Biodiversity and Conservation* **14**:601-615.
- Arguedas M., J. M. 1988. Coto Brus, cantón olvidado. *La Nación*, San José, Costa Rica, December 1.
- Armbrrecht, I., and I. Perfecto. 2003. Litter-twigg dwelling ant species richness and predation potential within a forest fragment and neighboring coffee plantations of

- contrasting habitat quality in Mexico. *Agriculture, Ecosystems and Environment* **97**:107-115.
- Associated Press Costa Rica. 2005. Starbucks ofrece en el mercado café de Tarrazú. *La Nación*, San José, Costa Rica, July 9.
- Associated Press Guatemala. 1994. Productores de banano no lograron consenso. *La Nación*, San José, Costa Rica, January 30.
- Bandeira, F. P., C. Martorell, J. A. Meave, and J. Cabellero. 2005. The role of rustic coffee plantations in the conservation of wild tree diversity in the Chinantec region of Mexico. *Biodiversity and Conservation* **14**:1225-1240.
- Barquero S., M. 1998. Caficultores temen crisis. *La Nación*, San José, Costa Rica, December 11.
- Barquero S., M. 1999. Caficultores temen crisis. *La Nación*, San José, Costa Rica, August 24.
- Barquero S., M. 2002. Beneficios en calle sin salida. *La Nación*, San José, Costa Rica, December 16.
- Barquero S., M. 2004a. Crisis del café cobra otra víctima. *La Nación*, San José, Costa Rica, August 6.
- Barquero S., M. 2004b. Denuncian "robo" de marca cafetera. *La Nación*, San José, Costa Rica, December 8.
- Barquero S., M. 2004c. Divisiones diferentes. *La Nación*, San José, Costa Rica, December 8.
- Barquero S., M. 2004d. Firmas pagan 50% más por café nacional de alta calidad. *La Nación*, San José, Costa Rica, November 11.
- Barquero S., M. 2004e. Temen cierre de una cooperativa cafetalera. *La Nación*, San José, Costa Rica, July 3.
- Barquero S., M. 2005. Caficultores afrontan aún graves secuelas de crisis. *La Nación*, San José, Costa Rica, May 2.
- Barrantes, M. G., and J. M. Pana. 2005. Migración interna en Costa Rica en el período 1927-2000. Instituto Nacional de Estadística y Censos, San José, Costa Rica. <http://www.inec.go.cr/06Publicaciones/07SerieCensal/21%20Migración%20interna%20en%20Costa%20Rica%20en%20el%20período%201927-2000/p17%20gomez.pdf>. Accessed March 22, 2005.

- Beer, J. 1987. Advantages, disadvantages and desirable characteristics of shade trees for coffee, cacao and tea. *Agroforestry Systems* **5**:3-13.
- Beer, J., R. Muschler, D. Kass, and E. Somarriba. 1998. Shade management in coffee and cacao plantations. *Agroforestry Systems* **38**:139-164.
- Bevan, D. L., P. Collier, and J. Gunning. 1990. Fiscal response to a temporary trade shock; the aftermath of the Kenyan coffee boom. *The World Bank Economic Review* **3**.
- Borrero, H., and J. Ignacio. 1986. La substitucion de cafetales de sombrío por caturales y su efecto negativo sobre la fauna de vertebrados. *Caldasia* **15**:71-75.
- Boucher, D. H. 1983. Coffee (Café). Pages 86-88 in D. H. Janzen, editor. *Costa Rican Natural History*. University of Chicago Press, Chicago, IL.
- Bray, D. B., J. L. P. Sánchez, and E. C. Murphy. 2002. Social dimensions of organic coffee production in Mexico: Lessons for eco-labeling initiatives. *Society and Natural Resources* **15**:429-446.
- Brenes, L. 2002. Nadie escapa de la crisis del café. *La Nación*, San José, Costa Rica, December 16.
- Briceño, J. A. 1992. Crisis del café y medidas compensatorias. *La República*, San José, Costa Rica, March 5.
- Brignoli, H. P. 1994. Naturaleza de las economías de exportación, con especial referencia a las economías cafetaleras. Pages 27-35 in M. S. K., editor. *Crisis y perspectivas del café latinoamericano*. Instituto del Café/Universidad Nacional, San José, Costa Rica.
- Burke, D. M., and E. Nol. 1998. Influence of food abundance, nest-site habitat, and forest fragmentation on breeding ovenbirds. *Auk* **115**:96-104.
- Burnham, K. P., and W. S. Overton. 1978. Estimation of the size of a closed population when capture probabilities vary among animals. *Biometrika* **65**:623-633.
- Burnham, K. P., and W. S. Overton. 1979. Robust estimation of the size of a closed population when capture probabilities vary among animals. *Ecology* **60**:927-936.
- Caramori, P. H., A. Androcioli-Filho, and A. C. Leal. 1996. Coffee shade with *Mimosa scabrella* Benth. for frost protection in southern Brazil. *Agroforestry Systems* **33**:205-214.
- Cardoso, C. 1973. La formación de la hacienda cafetalera en Costa Rica. *Revista de Estudios Sociales Centroamericanos* **6**.

- Chao, A. 1987. Estimating the population size for capture-recapture data with unequal catchability. *Biometrics* **43**:783-791.
- Chao, A. 2004. Species Richness Estimation in S. Kotz, B. Vidakovic, and N. Balakrishnan, editors. *Encyclopedia of Statistical Sciences*. John Wiley & Sons, New York, NY.
- Chazdon, R. L., R. K. Colwell, J. S. Denslow, and M. R. Guariguata. 1998. Statistical methods for estimating species richness of woody regeneration in primary and secondary rain forests of NE Costa Rica. Pages 285-309 in F. Dallmeier, and J. A. Komiskey, editors. *Forest biodiversity research, monitoring and modeling: conceptual background and Old World case studies*. Parthenon Publishing, Paris.
- The coffee crisis in the western hemisphere. 2002. Page 156. Subcommittee on the Western Hemisphere, Committee on International Relations, Washington, D.C.
- Colwell, R. K. 2001. User's Guide to EstimateS: Statistical estimation of species richness and shared species from samples. Department of Ecology and Evolutionary Biology, University of Connecticut, Storrs, CT.
<http://viceroy.eeb.uconn.edu/Estimates6/EstimateS%20Pages/UsersGuideHTML/EstiMateS6Guide.html>. Accessed June 30, 2003.
- Colwell, R. K. 2005a. EstimateS 7.5 User's Guide. University of Connecticut, Storrs, CT.
<http://viceroy.eeb.uconn.edu/EstimateS7Pages/EstS7UsersGuide/EstimateS7UsersGuide.htm>. Accessed June 6, 2005.
- Colwell, R. K. 2005b. EstimateS: Statistical estimation of species richness and shared species from samples. University of Connecticut, Storrs, CT.
- Cordero, F., R. Garcia, and A. Izquierdo 1987. *Economía y geografía del desarrollo en América Latina*. Fondo de Cultura Económica, Mexico.
- Corrales B., J. M. 1992. Crisis del café y riesgo democrático. *La Nación*, San José, Costa Rica, May 5.
- Coste, R. 2001. Coffee Production in I. *Encyclopedia Britannica*, editor. *Britannica 2001 Standard Edition CD-ROM*. Encyclopedia Britannica, Inc. Accessed October 15, 2004.
- Daily, G. C., P. R. Ehrlich, and G. A. Sanchez-Azofeifa. 2001. Countryside biogeography: use of human-dominated habitats by the avifauna of southern Costa Rica. *Ecological Applications* **11**:1-13.

- Daviron, B. 1994. La crisis del mercado cafetalero internacional an una perspectiva de largo plazo. Pages 11-26 in M. S. K., editor. Crisis y perspectivas del café latinoamericano. Instituto del Cafe/Universidad Nacional, San José, Costa Rica.
- Daviron, B., and F. Lerin. 1986. Le marché mondial du café. *Le Monde Diplomatique*.
- Defries, R., A. Hansen, A. C. Newton, and M. C. Hansen. 2005. Increasing isolation of protected areas in tropical forests over the past twenty years. *Ecological Applications* **15**:19-26.
- DGEC 1974. Costa Rica: Censo Nacional de Población y Vivienda 1973. Dirección General de Estadística y Censos, San José, Costa Rica.
- DGEC 1987. Censo Agropecuario 1984. Ministerio de Economía, Industria y Comercio, San José, Costa Rica.
- Dicum, G., and N. Luttinger 1999. *The Coffee Book: anatomy of an industry from crop to the last drop*. New Press, New York, NY.
- Dieni, J. S., and S. L. Jones. 2002. A field test of the area search method for measuring breeding bird populations. *Journal of Field Ornithology* **73**:253-257.
- DiFulvio, A. 1947. *Le Café dans le Monde*. UN Food and Agriculture Organization, Rome, Italy.
- Donald, P. F. 2004. Biodiversity impacts of some agricultural commodity production systems. *Conservation Biology* **18**:17-37.
- Dumas, M. 1992. Coffee into the next century: a trader's perspective. Page 17. 8th International Coffee Congress, Jerez de la Frontera.
- Dunlap, W. P. 1981. An interactive FORTRAN IV program for calculating power, sample size, or detectable differences in means. *Behavior Research Methods & Instrumentation* **13**:757-759.
- Edwards, S. 1984. Coffee, money and inflation in Colombia. *World Development* **11/12**.
- Eisemann, P. 1982. *L'organization Internationale du Commerce des Produits de Base*. Publication de la Faculté de Droit de Paris VI, Paris, France.
- EIU. 1991. Coffee to 1995: recovery without crutches. Special Report no. 21161, London.
- Engstrom, R. T., and F. C. James. 1981. Plot size as a factor in winter bird population studies. *Condor* **83**:34-41.

- Estrada, A., R. Coates-Estrada, and D. A. Meritt Jr. 1997. Anthropogenic landscape changes and avian diversity at Los Tuxtlas, Mexico. *Biodiversity and Conservation* **6**:19-43.
- Federación de Cafeteros de Colombia. 1978. 50 Años, 1927-1977. Boletín de información de estadística sobre café.
- Fernández, J. B. M., and G. P. Alvarez. 2004. Precio de Liquidación Final Cosecha 2003-2004. Instituto del Café de Costa Rica, San José, Costa Rica.
- Fernández, J. B. M., E. R. Rojas, and M. A. A. Molina 2000. Informe Sobre la Actividad Cafetalera de Costa Rica. Instituto del Café de Costa Rica, San José, Costa Rica.
- Fernández, J. B. M., E. R. Rojas, and M. A. A. Molina 2002. Informe Sobre la Actividad Cafetalera de Costa Rica. Instituto del Café de Costa Rica, San José, Costa Rica.
- FLO. 2005. Fair Trade Labeling Organizations International web site. Fair Trade Labeling Organizations International, Bonn, Germany. <http://www.fairtrade.net>. Accessed December 4, 2005.
- Geupel, G. R., C. J. Ralph, and S. L. Jones. 2003. The area search bird census: a habitat based method. Unpublished work.
- Gillison, A. N., N. Liswanti, S. Budidarsono, M. v. Noordwijk, and T. P. Tomich. 2004. Impact of cropping methods on biodiversity in coffee agroecosystems in Sumatra, Indonesia. *Ecology and Society* **9**:7-38.
- Gobbi, J. A. 2000. Is biodiversity-friendly coffee financially viable? An analysis of five different coffee production systems in western El Salvador. *Ecological Economics* **33**:267-281.
- Gotelli, N. J., and R. K. Colwell. 2001. Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters* **4**:379-391.
- Greenberg, R., P. Bichier, A. C. Angon, and R. Reitsma. 1996. Bird populations in shade and sun coffee plantations in Central Guatemala. *Conservation Biology* **11**:448-459.
- Greenberg, R., P. Bichier, and J. Sterling. 1997. Bird populations in rustic and planted shade coffee plantations of Eastern Chiapas, Mexico. *Biotropica* **29**:501-514.
- Gresser, C., and S. Tickell. 2002. Mugged: Poverty in your cup. 60 pp. Oxfam International, Oxford, UK.

- Griffith, D. M. 2000. Agroforestry: a refuge for tropical biodiversity after fire. *Conservation Biology* **14**:325-326.
- Grosser, K., J. Hudakand, and T. Ralston. 2005. The Community Agroecology Network (CAN) and The Evergreen State College: A presentation to the Farm to Table academic program. The Evergreen State College, Olympia, WA.
- Guevara M., J. D. 1993. Expertos analizan crisis cafetalera. *La Nación*, San José, Costa Rica, July 14.
- Gutiérrez, J. C. 1992. La crisis de la economía cafetera internacional y su impacto en los países productores. VIII Congreso Internacional del Café, Jerez de la Frontera.
- Harper, L. 1989. The persistence of ant-following birds in small Amazonian forest fragments. *Acta Amazonica* **19**:249-263.
- Hartshorn, G., L. Hartshorn, A. Atmella, L. D. Gómez, A. Mata, R. Morales, R. Ocampo, D. Pool, C. Quesada, C. Solera, R. Solórzano, G. Stiles, J. Joseph Tosi, A. Umaña, C. Villalobos, and R. Wells 1982. Costa Rica: Country Environmental Profile. Tropical Science Center, San José, Costa Rica.
- Hayek, L. C., and M. A. Buzas 1996. Surveying natural populations. Columbia University Press, New York.
- Heltshe, J., and N. E. Forrester. 1983. Estimating species richness using the jackknife procedure. *Biometrics* **39**:1-11.
- Hernandez Navarro, L. 1995. Café con aroma de burocracia. *La Jornada*, Mexico City, March 14.
- Hidalgo, G. 1983. Productividad de dos niveles tecnológicos usados en la producción de café en Costa Rica. VI Simposio de caficultura de Centroamérica, Panamá.
- Hietz, P. 2005. Conservation of vascular epiphyte diversity in Mexican coffee plantations. *Conservation Biology* **19**:391-399.
- Hilje, B., C. Naranjo, and M. S. Kutschbach. 1994. "No se puede dejar perder y no paga para los gastos." Testimonios de caficultores costarricenses ante la crisis. Pages 163-219 in M. S. K., editor. *Crisis y perspectivas del café latinoamericano*. Instituto del Café/Universidad Nacional, San José, Costa Rica.
- Holdridge, L. R. 1967. Life Zone Ecology. Tropical Science Center, San José, Costa Rica.
- Holdridge, L. R. 1971. Forest environments in tropical life zones: a pilot study. Pergamon Press, Oxford, New York.

- Holmes, B. 1996. Life on the edge. *New Scientist* **151**:38-39.
- Hughes, J. B., G. C. Daily, and P. R. Ehrlich. 2002. Conservation of tropical forest birds in countryside habitats. *Ecology Letters* **5**:121-129.
- ICAFFE. 1993. Informe Sobre la Actividad Cafetalera de Costa Rica. XXII Congreso Nacional Cafetalero. Instituto del Café de Costa Rica, San Jose, Costa Rica.
- ICAFFE. 1997. Informe Sobre la Actividad Cafetalera de Costa Rica. XXVI Congreso Nacional Cafetalero. Instituto del Café de Costa Rica, San Jose, Costa Rica.
- ICAFFE. 2003. Boletín de Precios y Mercado Internacional. Instituto del Café de Costa Rica, San José, Costa Rica.
- ICAFFE. 2005a. Café recibido acumulado: cosecha 0405. Instituto del Café de Costa Rica, San José, Costa Rica.
- ICAFFE. 2005b. Comportamiento Producción de Café. Instituto del Café de Costa Rica, San José, Costa Rica. <http://www.icafe.go.cr/newsite.nsf/repint025?OpenPage>. Accessed January 4, 2005.
- ICAFFE. 2005c. Sistema de Información. Instituto del Café de Costa Rica, San José, Costa Rica. <http://www.icafe.go.cr/newsite.nsf>. Accessed January 8, 2005.
- ICO. 2005a. Breakdown of exports of arabica and robusta for countries exporting both types of coffee. International Coffee Organization, London, England. <http://www.ico.org/prices/m1-a.htm>. Accessed May 24, 2005.
- ICO. 2005b. Coffee Trade Statistics. International Coffee Organization, London, England. <http://www.ico.org>. Accessed October 31, 2005.
- ICO. 2005c. Exports by exporting countries to all destinations. International Coffee Organization, London, England. <http://www.ico.org/prices/m1.htm>. Accessed November 21, 2005.
- ICO. 2005d. ICO Indicator prices: monthly and annual averages. Coffee Prices. International Coffee Organization, London, England. <http://www.ico.org/prices/p2.htm>. Accessed November 6, 2005.
- ICO. 2005e. Total production of exporting countries: Crop years 1999/00 to 2004/05. International Coffee Organization. <http://www.ico.org/prices/po.htm>. Accessed May 24, 2005.
- IGNCR. 1975. Cañas Gordas; Hoja 3642 III. Instituto Geográfico Nacional de Costa Rica, San José, Costa Rica.

- IGNCR. 1998. Costa Rica L13 1:40,000 98-12-26 Terra 14-15. Instituto Geográfico Nacional de Costa Rica, San José, Costa Rica.
- INEC 2001. IX Censo Nacional de Población y V de Vivienda del 2000: Resultados Generales. Instituto Nacional de Estadística y Censos, San José, Costa Rica.
- INEC. 2003a. Encuesta de hogares de propositos multiples: Cifras basicas sobre pobreza e ingresos. Page 6. Instituto Nacional de Estadística y Censos, San José, Costa Rica.
- INEC. 2003b. Encuesta de hogares de propositos multiples: Cifras basicas sobre pobreza e ingresos. Instituto Nacional de Estadística y Censos, San José, Costa Rica.
- INEC 2004. Censo Cafetalero: Aspectos metodológicos y principales resultados. Instituto Nacional de Estadística y Censos, San José, Costa Rica.
- Inter-American Development Bank, World Bank, and U. S. A. f. I. Development. 2002. Managing the competitive transition of the coffee sector in Central America. 38 pp. The coffee crisis and its impact in Central America: situation and lines of action, Antigua, Guatemala.
- IUCN. 2004. IUCN Red List of Threatened Species. International Union for the Conservation of Nature and Resources, Cambridge, UK. www.iucnredlist.org. Accessed December 1, 2005.
- Jiménez, M. F. 1994. From plantation to cup: the beverage of North American capitalism 1830-1930 in W. Roseberry, L. Gudmundson, and M. Samper, editors. Coffee, Society and Power in Latin America. Johns Hopkins, Baltimore, MD.
- Johnson, M. D. 2000. Effects of shade-tree species and crop structure on the winter arthropod and bird communities in a Jamaican shade coffee plantation. *Biotropica* **32**:133-145.
- Jules, E. S., and P. Shahani. 2003. A broader ecological context to habitat fragmentation: Why matrix habitat is more important than we thought. *Journal of Vegetation Science* **14**:459-464.
- Karnes, T. L. 2001. Costa Rica in I. Encyclopedia Britannica, editor. Encyclopedia Britannica. Encyclopedia Britannica, Inc. Accessed October 15, 2004.
- Klein, A.-M., I. Steffan-Dewenter, D. Buchori, and T. Tschardt. 2004. Effects of land-use intensity in tropical agroforestry systems on coffee flower-visiting and trap-nesting bees and wasps. *Conservation Biology* **16**:1003-1014.

- Komar, O. 2000. Effects of coffee shade trees on migratory bird abundance. IV Congress of the Mesoamerican Society for Biology and Conservation, Panama City, Panama.
- Komar, O. 2001. Effects on resident birds of shade trees in coffee plantations, and applications to coffee certification. Proceedings of the American Ornithologist's Union Conference, Seattle, WA, August 18.
- Kutschbach, M. S. 1994a. Crisis e Historia. Pages 11-26 in M. S. K., editor. Crisis y perspectivas del café latinoamericano. Instituto del Cafe/Universidad Nacional, San José, Costa Rica.
- Kutschbach, M. S. 1994b. Las caficulturas latinoamericanas en coyunturas críticas. Pages 79-131 in M. S. K., editor. Crisis y perspectivas del café latinoamericano. Instituto del Cafe/Universidad Nacional, San José, Costa Rica.
- Kutschbach, M. S. 1994c. Las fronteras del café: respuestas a la crisis u nuevas exploraciones. Pages 223-259 in M. S. K., editor. Crisis y perspectivas del café latinoamericano. Instituto del Cafe/Universidad Nacional, San José, Costa Rica.
- Lee, S. M., and A. Chao. 1994. Estimating population size via sample coverage for closed capture-recapture models. *Biometrics* **50**:1-11.
- Lindell, C. A., W. H. Chomentowski, and J. R. Zook. 2004. Characteristics of bird species using forest and agricultural land covers in southern Costa Rica. *Biodiversity and Conservation* **13**:2419-2441.
- Lindell, C. A., and M. Smith. 2003. Nesting bird species in sun coffee, pasture, and understory forest in southern Costa Rica. *Biodiversity and Conservation* **12**:423-440.
- Lindsey, B. 2003. Grounds for Complaint? Understanding the "coffee crisis." Trade briefing paper No. 16. The Cato Institute, Washington, D.C.
- Lovejoy, T. E., R. O. Bierregaard, A. B. Rylands, J. R. Malcolm, C. E. Quintela, L. H. Harper, K. S. Brown, A. H. Powell, G. V. N. Powell, H. O. R. Schubert, and M. B. Hays. 1986. Edge and other effects of isolation on Amazonian forest fragments. In M. E. Soule, editor. *Conservation Biology: the science of scarcity and diversity*. Sinauer Associates, Sunderland, Massachusetts.
- Luck, G. W., and G. C. Daily. 2003. Tropical countryside bird assemblages: Richness, composition, and foraging differ by landscape context. *Ecological Applications* **13**:235-247.

- Lugo, A. E. 1988. Estimating reductions in the diversity of tropical forest species. Pages 58-76 in E. O. Wilson, editor. Biodiversity. National Academy Press, Washington, D.C.
- Lyngbaek, A. E., R. G. Muschler, and F. L. Sinclair. 1999. Productivity, labour and variable costs of organic versus conventional coffee smallholdings in Costa Rica. Pages 216-219. Actas IV Semana Científica del CATIE. CATIE, Turrialba, Costa Rica, Turrialba, Costa Rica.
- Magurran, A. E. 1988. Ecological diversity and its measurement. Princeton University Press, Princeton.
- Magurran, A. E. 2004. Measuring Biological Diversity. Blackwell Publishing, Malden, MA.
- Manger, W. F. 1992. Colonization on the southern frontier of Costa Rica: a historical-cultural landscape. 251 pp. Department of Geography. Memphis State University, Memphis, TN.
- Marcano-Vega, H., T. M. Aide, and D. Báez. 2002. Forest regeneration in abandoned coffee plantations and pastures in the Cordillera Central of Puerto Rico. *Plant Ecology* **161**:75-87.
- Mason, D. 1996. Responses of Venezuelan understory birds to selective logging, enrichment strips, and vine cutting. *Biotropica* **28**:296-309.
- Messer, K. D., M. J. Kotchen, and M. R. Moore. 2000. Can shade-grown coffee help conserve tropical biodiversity? A market perspective. *Endangered Species Update* **17**:125-131.
- MGP 1986. Censo de población 1984. Ministerio de Gobernación y Policía, Imprenta Nacional, San José, Costa Rica.
- Moguel, P., and V. M. Toledo. 1999. Biodiversity conservation in traditional coffee systems of Mexico. *Conservation Biology* **13**:11-21.
- Montoya, Y. 2003. Café con aroma de mujer. *La Nación*, San José, Costa Rica, May 15.
- Mora, A. C. 2001a. Crisis sentencia a pequeño caficultores. *La República*, San José, Costa Rica, July 15.
- Mora, C. 2001b. Disminuye uso de agroquímicos. *La República*, San José, Costa Rica, January 27.
- Morales Ch., S. 1999. Prevén crisis cafetalera. *La Prensa Libre*, San José, Costa Rica, August 14.

- Morales, S. 2000. Café y banano débiles ante crisis. La República, San José, Costa Rica, December 19.
- Muñoz N., M. 1997. FONECAFE debe ser para crisis. La Prensa Libre, San José, Costa Rica, December 4.
- Murillo, N. 1994. Buscan salida a crisis de caficultura. La Nación, San José, Costa Rica, January 30.
- Murillo, N. 1996. Vivir del café. Pages 21-22. Rumbo.
- Murillo, N. 1999. Crisis ahoga productos tradicionales. La República, San José, Costa Rica, November 14.
- Murillo, W. 1992. Crisis cafetalera y bananera golpea a la América Latina. La República, San José, Costa Rica, June 10.
- Muschler, R. G. 1998. Tree-crop compatibility in agroforestry: Production and quality of coffee grown under managed tree shade in Costa Rica. 221 pp. Ph.D. dissertation, University of Florida.
- Muschler, R. G. 2001. Shade improves coffee quality in a sub-optimal zone of Costa Rica. *Agroforestry Systems* **51**:131-139.
- Nestel, D., F. Dickschen, and M. A. Altieri. 1993. Diversity of soil macro-Coleoptera in agroecosystems: an indication of habitat perturbation. *Biodiversity and Conservation* **2**:70-78.
- Numa, C., J. R. Verdú, and P. Sánchez-Palomino. 2005. Phyllostomid bat diversity in a variegated coffee landscape. *Biological Conservation* **122**:151-158.
- Nyhus, P., and R. Tilson. 2004. Agroforestry, elephants, and tigers: balancing conservation theory and practice in human-dominated landscapes of Southeast Asia. *Agriculture, Ecosystems and Environment* **104**:87-97.
- O'Brien, T. G., and M. F. Kinnaird. 2003. Caffeine and Conservation. *Science* **300**:587.
- O'Brien, T. G., and M. F. Kinnaird. 2004. Response to Dietsch, et. al. *Science* **303**:625-626.
- Osorio, N. 2005a. Coffee Market Report: May 2005. International Coffee Organization, London, England.
- Osorio, N. 2005b. Coffee Market Report: September 2005. International Coffee Organization, London, England.

- Osorio, N. 2005c. ICO submission to the G-8 Summit, Gleneagles, Scotland, 6-8 July 2005. International Coffee Organization, London, England.
- Owens, I. P., and P. M. Bennett. 2000. Ecological basis of extinction risk in birds: habitat loss versus human persecution and introduced predators. *Proceedings of the National Academy of Sciences* **97**:12144-12148.
- Palmer, M. W. 1991. Estimating species richness: the second-order jackknife reconsidered. *Ecology* **72**:1512-1513.
- Pelupey, W. 1991. Problemas relacionados con el nuevo Acuerdo Internacional del Café. *Aportes al Debate* **1**:18-31.
- Pelupey, W. 1993. El Mercado Mundial del Café: El Caso de El Salvador. Editorial Departamento de Investigaciones (DEI), San José, Costa Rica.
- Pelupey, W. 1997. The sustainability of international coffee chains in Cote d'Ivoire and Costa Rica. 38 pp. Symposium on Agricultural Marketing in Tropical Africa, Afrika Studicentrum & Vakgroep 'Marktkunde LUW.
- Pelupey, W., and E. v. Tilburg. 1994. El mercado solidario de café y el pequeño productor en Centroamerica. Pages 239-258 in M. S. K., editor. *Crisis y perspectivas del café latinoamericano*. Instituto del Café/Universidad Nacional, San José, Costa Rica.
- Pendergrast, M. 1999. *Uncommon grounds: The history of coffee and how it transformed our world*. Basic Books, New York, NY.
- Perfecto, I., A. Mas, T. Dietsch, and J. Vandermeer. 2003. Conservation of biodiversity in coffee agroecosystems: a tri-taxa comparison in southern Mexico. *Biodiversity and Conservation* **12**:1239-1252.
- Perfecto, I., R. A. Rice, R. Greenberg, and M. E. V. d. Voort. 1996. Shade coffee: a disappearing refuge for biodiversity. *Bioscience* **46**:598-606.
- Perfecto, I., and J. Vandermeer. 1996. Microclimatic changes and the indirect loss of ant diversity in a tropical agroecosystem. *Oecologia* **108**:577-582.
- Perfecto, I., and J. Vandermeer. 2002. Quality of agroecological matrix in a tropical montane landscape: ants in coffee plantations in Southern Mexico. *Conservation Biology* **16**:174-182.
- Perfecto, I., J. Vandermeer, P. Hanson, and V. Cartin. 1997. Arthropod biodiversity loss and the transformation of a tropical agro-ecosystem. *Biodiversity and Conservation* **6**:935-945.

- Petit, L. J., and D. R. Petit. 2003. Evaluating the importance of human-modified lands for neotropical bird conservation. *Conservation Biology* **17**:687-694.
- Philpott, S. M., and T. Dietsch. 2003. Coffee and conservation: a global context and the value of farmer involvement. *Conservation Biology* **17**:1844-1846.
- Pielou, E. C. 1975. *Ecological Diversity*. John Wiley & Sons, Inc., New York, NY.
- Pimentel, D., and U. Stachow. 1992. Conserving biological diversity in agricultural/forestry systems. *Bioscience* **42**:354-362.
- Pineda, E., and G. Halffter. 2004. Species diversity and habitat fragmentation: frogs in a tropical montane landscape in Mexico. *Biological Conservation* **117**:499-508.
- Pineda, E., C. Moreno, F. Escobar, and G. Halffter. 2005. Frog, bat, and dung beetle diversity in the cloud forest and coffee agroecosystems of Veracruz, Mexico. *Conservation Biology* **19**:400-410.
- Portilla R., W., and M. A. Araya M. 2002. Modelo de costos de producción agrícola de café. Page 20. Instituto del Café de Costa Rica, San José, Costa Rica.
- Portillo, L. 1993. El Convenio Internacional del Café y la crisis del mercado. *Comercio Exterior* **43**:378-391.
- Prendas, G. 2001a. Crisis cafetalera extiende sus tentáculos. *La República*, San José, Costa Rica, November 23.
- Prendas, G. 2001b. Pocas esperanzas para cafetaleros. *La República*, San José, Costa Rica, August 28.
- Prendas, G. 2002. Cafetaleros prevén recuperación de precios. *La República*, San José, Costa Rica, February 6.
- Puelschen, L., and H. J. Lutzner. 1994. Ecological and economic conditions of organic coffee production in Latin America and Papua New Guinea. *Angewandte Botanik* **67**:204-208.
- Quesada, and Marín. 2001. Cafetaleros preocupados. *Al Día*, San José, Costa Rica, December 10.
- Raaijmakers, J. G. W. 1987. Statistical analysis of the Michaelis-Menten equation. *Biometrics* **43**:793-803.
- Ramirez, O. A., and R. Sosa. 2000. Assessing the financial risks of diversified coffee production systems: an alternative nonnormal CDF estimation approach. *Journal of Agriculture and Resource Economics* **25**:267-285.

- Rappole, J. H., D. I. King, and J. H. V. Rivera. 2003a. Coffee and conservation. *Conservation Biology* **17**:334-336.
- Rappole, J. H., D. I. King, and J. H. V. Rivera. 2003b. Coffee and conservation III: Reply to Philpott and Dietsch. *Conservation Biology* **17**:1847-1849.
- Reeves, L. H., and R. J. Lilieholm. 1993. Reducing financial risk in agroforestry planning: a case study in Costa Rica. *Agroforestry Systems* **21**:169-175.
- Renjifo, L. M. 1999. Composition changes in a Subandean avifauna after long-term forest fragmentation. *Conservation Biology* **13**:1124-1139.
- Rice, R. A. 1999. A place unbecoming: the coffee farm of northern Latin America. *Geographical Review* **89**:554-579.
- Rice, R. A. 2001. Noble goals and challenging terrain: organic and fair trade coffee movements. *Journal of Agricultural and Environmental Ethics* **14**:39-66.
- Rice, R. A., and J. R. Ward. 1997. Coffee, conservation, and commerce in the Western Hemisphere. Smithsonian Migratory Bird Center and Natural Resources Defense Council, Washington, D.C.
- Roberts, D. L., R. J. Cooper, and L. J. Petit. 2000a. Flock characteristics of ant-following birds in premontane moist forest and coffee agroecosystems. *Ecological applications* **10**:1414-1425.
- Roberts, D. L., R. J. Cooper, and L. J. Petit. 2000b. Use of premontane moist forest and shade coffee agroecosystems by army ants in Western Panama. *Conservation Biology* **14**:192-199.
- Rogers, T. 2003. Starbucks to help Costa Rica weather world coffee crisis. *The Tico Times*, San José, Costa Rica, September 19.
- Rojas, J. R. 1988. Algunas observaciones sobre la caficultura de Coto Brus. Page 3. *Noticiero del Cafe*.
- Rojas, L., C. Godoy, P. Hanson, C. Kleinn, and L. Hilje. 2001. Hopper (Homoptera: Auchenorrhyncha) diversity in shaded coffee systems of Turrialba, Costa Rica. *Agroforestry Systems* **53**:171-177.
- Rojas, M. A. 2000. País ante dura crisis. *Al Día*, San José, Costa Rica, October 2.
- Rosemeyer, M., N. Viane, H. Swartz, and J. Kettler. 2000. The effect of slash/mulch and alleycropping bean production systems on soil microbiota in the tropics. *Applied Soil Ecology* **15**:49-59.

- Rowe, J. W. F. 1963. *The World's Coffee*. Her Majesty's Stationery Office, London, UK.
- Sanchez-Azofeifa, G. A. 2001. Deforestation in Costa Rica: A quantitative analysis using remote sensing imagery. *Biotropica* **33**:378-384.
- Sandoval, J. A. S. 2002. Coto Brus y el café: una breve reseña. *Boletín Informativo de La Regional Coto Brus, ICAFE* **2**:3-4.
- Sekercioglu, C. H. 2002. Forest fragmentation hits insectivorous birds hard. *Directions in Science* **1**:62-64.
- Sekercioglu, C. H., P. R. Ehrlich, G. C. Daily, D. Aygen, D. Goehring, and R. F. Sandi. 2002. Disappearance of insectivorous birds from tropical forest fragments. *Proceedings of the National Academy of Sciences* **99**:263-267.
- Sendieu, D. O. 1996. Impacts de la production du café sur l'environnement en Côte d'Ivoire in I. C. Organization, editor. *Seminar on Coffee and the Environment*.
- SEPSA 2002. *Boletín Estadístico Número 13*. Secretaria Ejecutiva de Planificación Sectorial Agropecuaria, San José, Costa Rica.
- Sherry, T. W. 2000. Shade coffee: a good brew even in small doses. *The Auk* **117**:563-568.
- Siebert, S. F. 2002. From shade- to sun-grown perennial crops in Sulawesi, Indonesia: implications for biodiversity conservation and soil fertility. *Biodiversity and Conservation* **11**:1889-1902.
- Smith, E. P., and G. v. Belle. 1984. Nonparametric estimation of species richness. *Biometrics* **40**:119-129.
- Sokal, R. R., and F. J. Rohlf 1995. *Biometry*. Freeman, New York, NY.
- Solórzano, J. D. T., and F. M. Fonseca. 2005. Costa Rica: una mapa de carencias críticas para el año 2000. Instituto Nacional de Estadística y Censos, San José, Costa Rica.
<http://www.inec.go.cr/06Publicaciones/07SerieCensal/11%20Costa%20Rica%20Un%20mapa%20de%20carencias%20críticas%20para%20el%20año%202000/p7%20mendez.pdf>. Accessed March 22, 2005.
- Soto-Pinto, L., I. Perfecto, J. Castillo-Hernandez, and J. Caballero-Nieto. 2000. Shade effect on coffee production at the northern Tzeltal zone of the state of Chiapas, Mexico. *Agriculture, Ecosystems and Environment* **80**:61-69.
- Stiles, F. G., G. P. Hewson, and L. D. Gomez 1996. *Checklist of the birds of Las Cruces Biological Station*. Organization for Tropical Studies, San José, Costa Rica.

- Stiles, G., and A. F. Skutch 1989. A Guide to the Birds of Costa Rica. Cornell University Press, Ithaca, New York.
- Stone, S. 1976. La dinastía de los conquistadores. Editorial Universitaria Centroamericana, San José, Costa Rica.
- Stouffer, P. C. 1998. Survival of the ant followers. *Natural History* **107**:40.
- Stouffer, P. C., and R. O. J. Bierregaard. 1995. Use of Amazonian forest fragments by understory insectivorous birds. *Ecology* **76**:2429-2445.
- Stratford, J. A., and P. C. Stouffer. 1999. Local extinctions of terrestrial insectivorous birds in a fragmented landscape near Manaus, Brazil. *Conservation Biology* **13**:1416-1423.
- Thiollay, J. M. 1995. The role of traditional agroforests in the conservation of rain and forest bird diversity in Sumatra. *Conservation Biology* **9**:335-353.
- Thompson, J., N. Brokaw, J. K. Zimmerman, R. B. Waide, E. M. E. III, D. J. Lodge, C. M. Taylor, D. García-Montiel, and M. Fluet. 2002. Land use history, environment, and tree composition in a tropical forest. *Ecological Applications* **12**:1344-1363.
- TransFairUSA. 2004a. Backgrounder: Fair Trade Certified™ coffee. TransFairUSA, Oakland, CA. http://www.transfairusa.org/pdfs/backgrounder_coffee.pdf. Accessed December 4, 2005.
- TransFairUSA. 2004b. Fast facts: Fair Trade Certified™ coffee. TransFairUSA, Oakland, CA. http://www.transfairusa.org/pdfs/fastfacts_coffee.pdf. Accessed December 4, 2005.
- TransFairUSA. 2005. Fair trade certification. TransFairUSA, Oakland, CA. [http://www.transfairusa.org/pdfs/certification_overview\(4.05\).pdf](http://www.transfairusa.org/pdfs/certification_overview(4.05).pdf). Accessed December 4, 2005.
- U.S. Agency for International Development. 2003. USAID's response to the global coffee crisis (fact sheet). U.S. Agency for International Development, Washington, D.C.
- U.S. Department of Labor. 2004. Consumer Price Index 1913-2004. U.S. Department of Labor Bureau of Labor Statistics. <ftp://ftp.bls.gov>. Accessed September 17, 2004.
- U.S. Naval Observatory. 2005. Complete sun and moon data for one day. U.S. Naval Observatory, Astronomical Applications Department, Washington, D.C. http://aa.usno.navy.mil/data/docs/RS_OneDay.html. Accessed October 30, 2005.
- Ulate, A. A. 1997. Fe en el café. Pages 16-17. Rumbo.

- Ulett, L. 2001. Cafés finos solucionarían crisis. La República, San José, Costa Rica, July 4.
- UNFAO 1995. Production Yearbook. UN Food and Agriculture Organization, Rome, Italy.
- UNFAO 1999. State of the world's forests 1999. United Nations Food and Agriculture Organization, Rome, Italy.
- UNFAO 2001. State of the World's Forests 2001. United Nations Food and Agriculture Organization, Forestry Department, Rome, Italy.
- UNFAO. 2005. FAOSTAT Agriculture Data. United Nations Food and Agriculture Organization. <http://apps.fao.org/default.jsp>. Accessed October 31, 2005.
- USAID. 2003. USAID fact sheet: USAID's response to the global coffee crisis. U.S. Agency for International Development, Washington, D.C.
- USAID. 2004. USAID fact sheet: USAID supports coffee growers around the globe. U.S. Agency for International Development, Washington, D.C.
- Valverde, L. 2002. Crisis atascó desarrollo en zonas cafetaleras. La República, San José, Costa Rica, August 5.
- Vandermeer, J., and I. Perfecto. 1997. The agroecosystem: a need for the conservation biologist's lens. *Conservation Biology* **11**:1-3.
- Varangis, P., P. Siegel, D. Giovannucci, and B. Lewin. 2003. Dealing with the coffee crisis in Central America: impacts and strategies. Policy research working paper 2993. World Bank, Washington, D.C.
- Vargas, R. R. 1993. Experimentos en café para enfrentar la crisis. La República, San José, Costa Rica, June 19.
- Vega M., L. 1992. Medidas para conjurar crisis cafetalera no deben demorarse. La República, San José, Costa Rica, February 11.
- Viquez, A. S. 1992a. Crisis amenaza a los pequeños cafetaleros. La República, San José, Costa Rica, July 2.
- Viquez, A. S. 1992b. Se agrava crisis en Coto Brus. La República, San José, Costa Rica, July 24.
- VNKT. 1987. Jaarverslag.

- Vorst, C. R. 1986. Desarrollo economico, estructura y contradicciones sociales an la produccion de café. *Revista de Historia* **14**:179-195.
- Wa-chong, T. G. 2001. Cafetaleros sin dinero para pagarle a recolectores. *La Prensa Libre*, San José, Costa Rica, October 30.
- Wasserman, M. 2002. Trouble in coffee lands. *Federal Reserve Bank of Boston Regional Review* **12**:4-13.
- Wattel, C. J., M. v. d. Boogaard, R. Ruben, and J. P. d. Groot 1991. *Preferentiële Handelsvoorwaarden voor Kleine Koffieboeren*, San José, Costa Rica/Amsterdam, Netherlands.
- Wild, A. 2004. *Coffee: a dark history*. W.W. Norton & Company, New York, NY.
- Williams, R. G. 1994. *States and social evolution: coffee and the rise of national governments in Central America*. University of North Carolina Press, Chapel Hill, NC.
- Wilson, S. 2001. Coca invades Colombia's coffee fields: falling prices push farmers to plant illegal crops, threatening U.S. drug war. *The Washington Post*, October 30.
- Winson, A. 1989. *Coffee and Democracy in Modern Costa Rica. Between the Lines*, Toronto, Ontario.
- Woodroffe, R., and J. R. Ginsberg. 1998. Edge effects and the extinction of populations inside protected areas. *Science* **280**:2126–2128.
- World Bank Group. 2003. *Costa Rica at a Glance*. The World Bank Group.
- World Bank Group. 2005a. *Costa Rica at a glance*. World Bank Group. http://devdata.worldbank.org/AAG/cr_i_aag.pdf. Accessed November 18, 2005.
- World Bank Group. 2005b. *World Development Indicators Database*. The World Bank Group. <http://www.worldbank.org>. Accessed November 18, 2005.
- Young, C. M. 2003. Coffee agroforestry systems for conservation and economic development: A case study of the AMISCONDE initiative in a buffer zone community of Costa Rica. *Journal of Sustainable Forestry* **6**:39-63.
- Zanette, L., P. Doyle, and S. M. Tremont. 2000. Food shortage in small fragments: evidence from an area-sensitive passerine. *Ecology* **81**:1654-1666.
- Zeledón, V. F. 1987. *Campesinos luchan contra selva y lodo en Coto Brus*. La República, San José, Costa Rica, August 17.